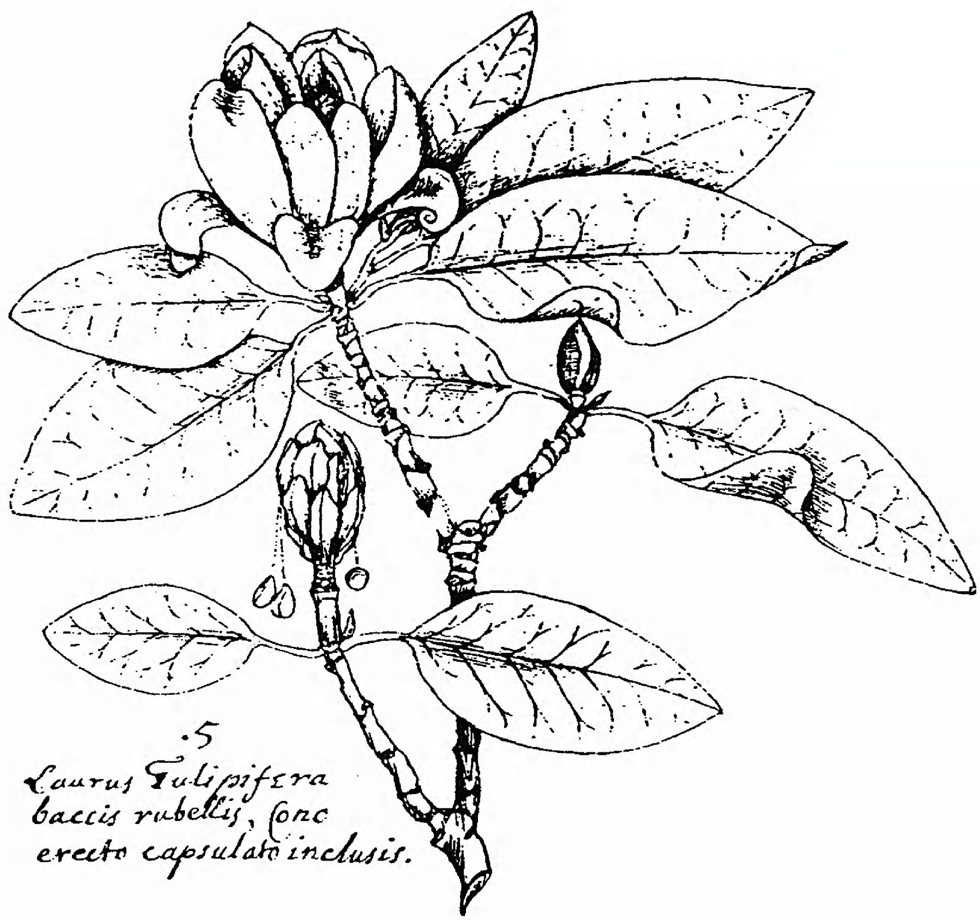
BANISTERIA

A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA



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Cover: Sweetbay (*Magnolia virginiana*); drawing by John Banister; sent to Bishop D. H. Compton in 1689.
Inner back cover: Copperhead (*Agkistrodon contortrix*) from Greene County, Virginia; photographic illustration by Will Brown.

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Number 25, 2005

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Results of a Herpetofaunal Survey of the Radford Army Ammunition Plant in Southwestern Virginia

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ABSTRACT

A two-year inventory of reptiles and amphibians was conducted in 1997-1998 at the Radford Army Ammunition Plant in southwestern Virginia. Eight survey techniques (time-constrained surveys, drift fences, pitfall traps, call surveys, road surveys, dip nets, cover boards, and hoop and basking traps) were used. Results included sightings or captures of 531 frogs and toads (8 species), 467 salamanders (11 species), 30 turtles (4 species), 13 lizards (1 species), and 51 snakes (9 species). A new distribution record for *Pseudacris feriarum* in Pulaski County was noted and the first occurrence of albinism in the genus *Pseudotriton* was documented. Based on relative abundance estimates from time-constrained surveys and drift fence captures, average abundance and species richness was generally greater in wetland and riparian areas, moderate to high in deciduous woods and woodlots, and low in grasslands and pine plantations. Qualitative comparison of the different survey techniques suggests that time-constrained surveys and drift fences with funnel traps were the most effective techniques used in this survey.

Key words: reptile, amphibian, relative abundance, habitat, albinism, techniques, Virginia.

INTRODUCTION

Biological inventories document spatial distributions of individuals, populations, species, guilds, communities, and ecosystems (Kremen et al., 1993). They provide valuable information and form the basis for sound wildlife management practices. Kremen et al. (1993) described four uses of inventory data: (1) to select and design reserves; (2) to assess the potential for sustainable use of natural resources; (3) to strengthen the case for habitat conservation by documenting the distribution of threatened or endangered species; and (4) to provide the basis for selecting indicator species or assemblages for ecological monitoring. In addition, inventories can provide baseline data from which the effects of management practices may be assessed, determining species-habitat associations and species assemblages.

Many land management agencies have been developing management plans with or without baseline wildlife inventories. The U.S. Forest Service is mandated to develop forest plans that guide their management activities over a period of 10 years. State wildlife agencies manage lands often for a single species or small group of species. Often these plans are developed with little baseline inventory data to either plan management activities or assess their implications, typically because of manpower or financial constraints.

Under the Sikes Act as amended by the Sikes Act Improvement Act of 1997, the U.S. Department of Defense (USDOD) is mandated to provide for the

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conservation and rehabilitation of natural resources on lands used for military mission activities. Integrated Natural Resources Management Plans (INRMPs) are the means by which the USDOD is fulfilling its mandate. To assist with preparation of INRMPs, the U.S. Army has guidelines that identify the need for "planning level surveys" that can make a significant contribution toward the understanding and management of existing resources. These surveys should minimally include flora, fauna, plant communities, and threatened and endangered species.

This report describes the results of a reptile and amphibian survey that was part of a complete zoological inventory conducted at Radford Army Ammunition Plant (RAAP) by the Virginia Department of Game and Inland Fisheries (VDGIF) in 1997 and 1998. The inventory was conducted to provide a zoological record of species present at RAAP, particularly those that are rare or protected, and to identify their distribution and habitat associations. The inventory has provided data on which to base, in part, an INRMP developed by RAAP (Chase, 1998). The primary objectives of the herpetological survey were to obtain species presence/absence data, as well as to describe the distribution and habitat associations of species within RAAP. In addition, natural history and baseline abundance data were collected, and we provide some brief discussion concerning the efficacy of each sampling technique applied in the survey.

STUDY AREA

Physical Characteristics

RAAP is located in Montgomery and Pulaski counties in southwestern Virginia and is divided into two separate parcels, the Main and the New River facilities. The Main Facility covers an area of 1,710 ha located approximately 5 km NNE of the City of Radford, Virginia. It is intersected by the New River, which forms the boundary between Montgomery and Pulaski counties. The New River Facility covers an area of approximately 1,560 ha. It is located 8.3 km SW of the Main Facility and ca. 2 km E of Dublin, Virginia and is entirely within Pulaski County. RAAP is a USDOD industrial complex operated by a private contractor, currently Alliant Techsystems, Inc.

RAAP lies within the New River Valley region of the Ridge and Valley physiographic province of Virginia. Elevation ranges from 519 to 625 m and is generally characterized as rolling to strongly rolling; sections of the New River through the Main Facility are bordered by nearly vertical limestone bluffs reaching heights up to 100 m above the river. The New River Valley crosses the Ridge and Valley province approximately perpendicular to the regional strike of bedrock, mainly cutting Cambrian and Ordovician limestone or dolomite. Most of RAAP is underlain by the Elbrook Formation (Cambrian) except for a small area in the easternmost section of the Main Facility that is underlain by the McCrady/Price Formation (Mississippian) bedrock (Chase, 1998). Karst features such as springs and caverns occur throughout the Elbrook Formation at RAAP.

Biotic Communities

RAAP contains six natural plant communities. Upland Forests are hardwood-dominated communities with moisture gradients ranging from dry to mesic; Limestone Barrens are grass-dominated communities underlain by dolomitic limestone with thin, weathered soils and scattered bedrock exposures; Xeric Calcareous Cliffs occur on exposed limestone cliffs with steep south- and west-facing bluffs of the New River; Calcareous Fens are permanently to semi-permanently saturated soils fed by mineral-rich waters of relatively high pH; Piedmont/Mountain Bottomland Forests are hardwood-dominated systems that occur on stream and river floodplains, particularly of the New River and Stroubles Creek; Sand/Gravel/Mud Bar and Shore is open shoreline and bar habitat along the New River, primarily of course to fine-grained alluvium with small bedrock exposures. Four artificial communities were defined at RAAP: Grasslands are a combination of old fields (still open, but abandoned agricultural fields), meadows of forbs and warm and cool season grasses (mowed annually to semi-annually), and fields cultivated for wildlife cover and forage; Successional Woodland/Forest is an artificial successional community characterized by the presence of a few colonizing woody species and weedy herbaceous species; Pine Plantations are mature pine forests planted primarily for timber harvest, and are composed of loblolly (*Pinus taeda*), white (*P. strobus*), and shortleaf (*P. echinata*) pine; Wet Meadow/Marsh and Ponds are areas of saturated soil conditions supporting an array of herbaceous and emergent hydrophytic vegetation, most of which were created by drainage ditching practices or pond creation. Complete descriptions of these communities are provided in VDGIF (1999).

The New River at the Main Facility ranges from 75 to 300 m in width and is gradually sloping. Meanders are large and depths vary from a few centimeters at cross-sectional bedrock faults to several meters in pools; vegetated, rocky bars are common. Streams at the Main Facility are relatively stable systems with

adequate forest buffers, providing good riparian and wildlife aquatic habitat, while most stream sections of the New River facility have been impacted by past and ongoing agricultural practices, and in most cases do not support woody riparian vegetation. Natural wetlands occur at both facilities in the form of hillside seepages, stream floodplain wetlands, ponded sinkholes, and springheads. A small calcareous fen occurs at the New River Facility harboring several rare plants, and a few small, isolated depression wetlands occur on the New River terrace at the southeastern corner of the Main Facility. Although indicators (e.g., seasonally saturated soils and hydrophytic plant communities) suggest the New River terrace at RAAP may have historically supported palustrine wetlands, hydrology has been effectively removed through ditching practices. Drainage ditches within the terrace direct slow-moving water and most support cattail (*Typha latifolia*) as the dominant wetland plant species. At least 12 man-made lacustrine systems occur in the form of wastewater storage lagoons, stormwater retention ponds, and wildlife impoundments. Like the drainage ditches, most of the impoundments are eutrophic and support small adjacent marshes and shorelines dominated by cattails and rushes (*Juncus* spp.).

Land Use Practices

Land use at RAAP is comprised primarily of industrial areas, maintained grasslands and agricultural fields, mixed deciduous forest and woodland patches of various stand age, and pine plantations. While the core regions of both facilities support either industrial or cleared land, RAAP has maintained a forested buffer around most of the perimeter of each facility for noise buffering and aesthetics (Chase, 1998). The buffers contain several large, mature mixed-deciduous tracts, successional woodlands, and pine plantations. Pine plantations are located on areas of low to moderate relief (covering more than half of the New River bottomland) of both facilities, while the deciduous component occurs on steeper slopes or in areas with numerous sinks and depressions.

Present and historically-maintained agricultural grasslands comprise roughly 75% of the total RAAP area in the form of old fields, open meadows, hay fields, and cropland. Grassland areas are maintained primarily for safety and fire suppression reasons, and approximately 195 ha are leased to area farmers for hay production. VDGIF currently manages wildlife plantings in grassland areas for White-tailed Deer (*Odocoileus virginiana*), Wild Turkey (*Meleagris gallopavo*), and Northern Bobwhite (*Colinus virginianus*). Grasslands in production areas are mowed frequently, although grasslands in storage areas are mowed only once or twice per year; and some wildlife plots are mowed only once every three to five years. Storage areas are almost entirely managed as grasslands and cover large areas: roughly 150 and 350 ha of contiguous area at the Main and New River facilities, respectively.

To our knowledge there have been no previous, extensive herpetological surveys at RAAP, although Richard Hoffman (pers. comm.) mentioned finding *Pseudotriton ruber* and other salamanders at springheads while collecting invertebrates on the base. There are, however, a few preserved specimens at the Main Facility's Maintenance Building (dates and collector[s] unknown), which include *Agkistrodon contortrix*, *Lampropeltis triangulum*, and *Coluber constrictor*. In addition, remains of *Terrapene carolina*, *Chrysemys picta*, *Pseudemys concinna*, and *Sternotherus odoratus* were unearthed at archeological sites at the Main Facility (Barber & Tolly, 2002), and thus occurred there historically.

MATERIALS AND METHODS

Survey sites were selected based on plant community/habitat type representation and accessibility. When feasible, data gathered for each specimen collected or observed included age, sex, and snout-vent length (SVL) or carapace length (CL). Calipers were used for all measurements less than 18 cm. Individuals captured using trapping techniques were marked to avoid double counting: snakes were marked by notching ventral scales with a "V" midway along the body length each time an individual was captured, with subsequent notches placed on the next most posterior scale; turtles were marked using a numbering scheme (by filing notches in marginal scutes of the carapace) as described by Dodd (2001); and amphibians by clipping the outer-most toe of the right anterior limb, with subsequent captures clipping the next anterior-most toe. Individuals were not marked or measured during time-constrained surveys if capture was unnecessary for identification purposes. Additional data collected at each site included site designation, habitat type, date, time, and general weather conditions.

Eight sampling techniques (time-constrained surveys, drift fences, pitfall traps, call surveys, road surveys, dip nets, cover boards, and hoop and basking traps) were used to sample the herpetofauna at RAAP. Detailed information concerning sample locations is provided in VDGIF (1999). A description of each sampling technique follows.

Time-constrained Survey: Time-constrained surveys were conducted by visually searching prime

microhabitat sites (n = 36) within general habitat types, and documenting the time (min) spent searching each area (Bury & Raphael, 1983). Surveys were usually conducted during the day and predominantly in terrestrial habitats, although searches in aquatic/riparian zones of streams and the New River were also included in this technique. Relative abundance (Captures per Unit Effort [CPUE]) was determined for each survey site by dividing the total number of captures and/or observations by the total time spent conducting searches. To curtail repeat counting of individuals at sites that were visited more than once, only the session with the highest number observed of a given species was used in abundance estimations. Because larval amphibians tend to be concentrated in riparian areas and could bias results (Welch, 1987), aquatic larvae were excluded from abundance estimates.

Drift Fence Survey: Drift fences with pitfall and funnel traps (n = 11) were constructed using siltation fencing. In terrestrial habitats, Y-shaped arrays were constructed in a fashion similar to that used by Jones (1981). For ponds, three separate fence segments were evenly spaced around the pond perimeter and within 5 m of the water's edge; pitfall traps were placed at both ends of each fence segment. Fence segments were approximately 0.6 m tall and 9 m long for both array types. Nineteen-l buckets were used as pitfall traps; however, occasionally rocky substrate required the use of 9.5-l buckets. Holes were made in the bottom of each bucket to allow for drainage and funnel inserts constructed from galvanized tin were placed in pitfall openings. To prevent rainwater collection and to deter predators, bucket lids were propped with metal stakes approximately 10 cm directly above pitfall openings. Funnel traps were constructed from window screen material as described by Campbell & Christman (1982), measuring 76 cm in length and 20 cm in diameter. These were placed mid-way along both sides of each fence segment and held in place with pliable metal stakes. Generally, drift fence arrays were left open from late winter to mid-summer and then again in the Fall. Arrays were checked daily when first opened and every 2-3 days thereafter. Funnel traps were inverted and covers were placed over all pitfalls during periods of non-use. Relative abundance (CPUE) was determined for each array by dividing the total number of captures by the total number of array-nights (Heyer et al., 1994).

Pitfall Trap Survey: Pitfall traps were constructed by removing the top one-fourth of a 2-l soda bottle and burying the opening flush with the ground. These were arranged in arrays of 8, with two rows of four; spacing between pitfalls was approximately 10 m. Each pitfall was located adjacent to a log or fallen tree that could act as a suitable drift fence. Pitfalls were filled with 10% formalin to approximately 10 cm below the opening and were checked once every 2-3 weeks.

Anuran Call Survey: Anuran call surveys were conducted at wetlands and open-water ponds during rainy nights when the ambient temperature was above 10°C. Surveys were conducted by recording the species and number of individuals calling (if possible) during a 10 min period. Incidences when many individuals of the same species were calling simultaneously were recorded as choruses. We also documented anuran calls heard incidentally throughout the field season.

Nighttime Road Survey: Road surveys were performed by driving roads within the facilities during rainy nights when the temperature was above 10°C, often in conjunction with anuran call surveys. This was accomplished by driving slowly with the headlights and a spotlight directed on the road center just ahead of the vehicle. A specific route was not established for this technique, but was directed selectively along roadways near wetlands and ponds.

Cover Board Survey: Cover boards were constructed from 5-V galvanized tin roofing and measured 60 x 100 cm. Cover boards were laid in arrays of 10 within a specific habitat type. Arrays were configured in one or two rows with cover-boards placed approximately 5 m apart. One array was placed in each of six habitat types (deciduous woods, pine plantation, grassland, limestone cliff, calcareous fen, and wetland marsh). Three arrays were relocated during the second year of the study. Arrays were checked weekly.

Dip Net Survey: Dip netting was performed in palustrine habitats by extending a D-frame dip net approximately 2 m out from the water's edge and drawing the net inward to the shoreline along the bottom. This was performed repeatedly around the entire perimeter of the wetland while documenting the number of sweeps. Larvae of each species were counted and placed in a bucket, then released after completion of sampling. Species that could not be readily identified were kept in captivity until metamorphosis.

Hoop and Basking Trap Survey: To capture aquatic turtles, unbaited hoop traps and a basking trap were used on a limited basis in the New River. Hoop traps were installed by attaching the hoop apparatus to the shoreline and extending the driftnet downstream at a 30° angle to the shoreline. A basking trap was constructed by attaching a submerged chicken wire cage (120 x 60 x 60 cm) to a known basking log with the opening flush with the water surface.

Voucher specimens obtained during this study have been deposited in the collection of the Virginia Museum of Natural History in Martinsville.

RESULTS AND DISCUSSION

Trap Success by Survey Technique

Adults and subadults of 531 frogs and toads (8 species), 467 salamanders (11 species), 30 turtles (4 species), 13 lizards (1 species), and 51 snakes (9 species) were detected at RAAP (Table 1). Two species, *Agkistrodon contortrix* and *Rana palustris*, were not detected using any of the applied survey techniques, but were found incidentally. A new distribution record for *Pseudacris feriarum* in Pulaski County was noted and the first occurrence of albinism in the genus *Pseudotriton* was documented (Garriock, 2000). No federal or state-listed reptile or amphibian species were found during the survey (Mitchell, 1991; Roble, 2001). A summary of observations and captures by survey technique is provided in Table 1.

Time-Constrained Surveys – Time-constrained surveys were conducted at 36 sites in differing habitat types described as deciduous woods and woodlots (n = 7), grasslands, old fields, and maintained fields (n = 8), pine plantations (n = 4), sun-exposed limestone talus (n = 3), vegetated wetlands (n = 3), and intermittent to perennial streams (n = 11). A total of 52 survey-hr resulted in the capture or observation of 207 individuals of 28 species (15 amphibians and 13 reptiles) (Table 1). Survey sites were visited from 1-8 times, but most often twice, during both years combined. Of the specimens collected or observed, 13% were anurans, 59% were salamanders, 8% were turtles, 14 % were snakes, and 6% were *Sceloporus undulatus*, the only lizard species detected. Time-constrained surveys were the best technique for finding each taxonomic group except anurans (specifically *Pseudacris crucifer* and *P. feriarum*). Copperheads were not found during our searches, although they were rumored to be common in some areas of the base, suggesting that other less common snakes such as *Heterodon platirhinos* and *Opheodrys aestivus* may have been missed during our searches. Detection of new species leveled off after 39 h of cumulative survey time (Fig. 1), and discovery of new species would have required a great deal of additional searching. Time-constrained surveys resulted in the highest number of species detected (82% of all amphibian and reptile species detected at RAAP), including five species that were not found using other survey techniques. Our results concur with other studies suggesting that this is the most effective survey technique for determining species richness and relative abundance of terrestrial herpetofauna (Bury & Raphael, 1983; Welch, 1987).

Drift Fence Surveys - Eleven arrays were established within the following habitat types: deciduous woods and woodlots (n = 4), grasslands (n = 2), pine plantations (n = 2), and ephemeral and permanent ponds (n = 3). Arrays were opened for a total of 751 trap nights and resulted in the capture of 725 individuals of 14 amphibian and five reptile species (57.6% of all species detected at RAAP) (Table 1). Of the species captured using this technique, 57.4% were anurans, 40.4% salamanders, 0.8% turtles, and 1.4 % snakes. All species detected by drift fence arrays were also detected using other techniques. The percentage of recaptures was much lower than expected (only 1.7% of all captures in 1998). Funnel traps accounted for 10% of all array captures, and only two species, *Coluber constrictor* and *Elaphe alleghaniensis*, were captured in funnel traps but not pitfalls. Lower capture rates for funnel traps compared to pitfalls has been documented (Bury & Corn, 1987; Greenberg et al., 1994) along with their effectiveness for capturing snakes (Bury & Corn, 1987; Fitch, 1992). Effectiveness of funnel traps is also known to vary among habitat types and herpetofaunal community composition (Greenberg et al., 1994) (e.g., drift fences around a known anuran breeding pond only detected one individual each of *Hyla versicolor* and *P. feriarum*, presumably because these species were able to climb the fences). However, this was the most effective technique (compared to time-constrained surveys and dip netting) for comprehensive sampling of confined aquatic areas. Installation of each drift fence array was labor intensive and required 2-3 man-hours for proper installation, and subsequent checking and maintenance of each array required much additional time. However, drift fence arrays resulted in nearly twice the number of captures as all other techniques combined. This, coupled with very effective capture of small mammals and terrestrial invertebrates, and as a reliable means of determining relative abundance, made this technique worthwhile.

Pitfall Trap Surveys - Pitfall arrays were established within deciduous woods and woodlot (n = 3), grassland (n = 1), pine plantation (n = 1), and old field (n = 1) habitat types. This was the only survey technique applied in the bottomland hardwoods plant community due to poor accessibility of areas outside the Main Facility perimeter fence. Pitfall traps were open from early April 1998 to early November 1998 and resulted in the capture of 42 specimens of nine species (one snake, one turtle, two anurans, and five salamanders) (Table 1). Seventy-four percent of all captures were salamanders collected in deciduous woods and riparian habitats, while anurans and reptiles represented 19% and 7%, respectively. No species was detected exclusive of other techniques. Installation of the pitfall traps was rapid and simple, and the arrays required little maintenance beyond having to periodically replenish

Table 1. Number of reptiles and amphibians counted and number of species detected for each survey technique (1997 and 1998 combined).

Species	Survey Technique[1] DF(PF)	DF(FT)	KT	TC[2]	RC	CB	AC[3]	DN[3]	HT	BT	Total No. Individuals
Bufo americanus	71	9	2	3	56		*				141
Hyla versicolor	1			3	1		*				5
Pseudacris crucifer	80	12			15		*				107
Pseudacris feriarum	1	1			3		*	*			5
Rana catesbeiana	6	5		12			*	*			23
Rana clamitans				8	2		*	*			10
Rana sylvatica	230		6	1	3		*	*			240
Ambystoma jeffersonianum	56	2		2	4			*			64
Ambystoma maculatum	3				13			*			16
Desmognathus fuscus	3		2	29	1						35
Desmognathus quadramaculatus				11							11
Eurycea cirrigera	22	5	10	22		1					60
Eurycea longicauda	3	4		9							16
Notophthalmus viridescens	3			2				*			5
Plethodon cinereus	132	9	12	21							174
Plethodon glutinosus			2	7							9
Plethodon wehrlei	38	13	5	12		1					69
Pseudotriton ruber				8							8
Chelydra serpentina	1			3					4		8
Chrysemys picta				9							9
Pseudemys concinna				2						2	4
Terrapene carolina	1	4	2	2							9
Sceloporus undulatus				13							13
Carphophis amoenus			1	1							2
Coluber constrictor		1		2							3
Diadophis punctatus				2		2					4
Elaphe alleghaniensis		1		5							6
Lampropeltis triangulum				3		1					4
Nerodia sipedon				5		3					8
Regina septemvittata				4							4
Thamnophis sirtalis	3	5		6		6					20
Total No. Individuals	654	71	42	207	98	14	--	--	4	2	1092
Total No. Species	17 (DF combined: 19)	13	9	28	9	6	7	7	1	1	31

[1] DF(PF) = drift fence pitfall; DF(FT) = drift fence funnel trap; KT = formalin pitfall; TC = time-constrained survey; RC = road cruising; CB = coverboard; AC = anuran call survey; DN = dip net; HT = hoop trap; BT = basking trap

[2] Does not include larvae; no species were detected as larvae that were not detected as adults

[3] Presence/absence provided for anuran call and dipnet surveys; presence represented by an asterisk

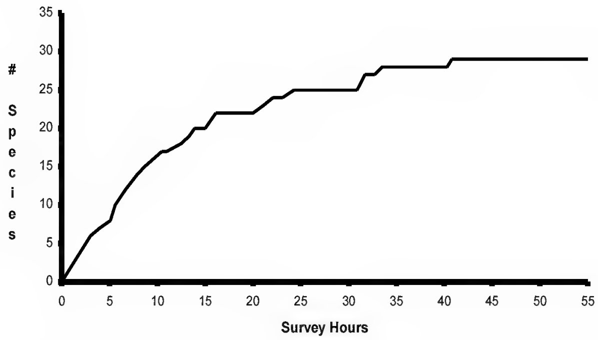

Fig. 1. Species accumulation curve for time-constrained surveys in 1997 and 1998 at RAAP.

the formalin. There are drawbacks to use of formalin worth mentioning: first, on occasion the pitfall concentration was diluted during heavy rain or flooding events and had to be replaced prematurely; secondly, the chemical can be expensive and difficult to obtain; and last, skin exposure is considered by some to be a health risk. Generally speaking, this method was relatively ineffective at sampling the herpetofauna when compared to drift fence arrays. Bury & Corn (1987) also found low capture rates in their evaluation of pitfall-only designs. Pitfall trap surveys were useful for sampling restricted areas where it would have been impractical to check live traps on a daily basis. Pitfalls were also productive at sampling small mammals and invertebrates, but less so than drift fence arrays.

Anuran Call Surveys - Anuran call surveys were conducted on nine separate nights at 11 different sites between April 1997 and September 1998. Each site was surveyed an average of two times. A total of seven anuran species was detected at both facilities combined, representing all but one of the species documented at RAAP (Table 1; *Rana palustris* was heard calling incidentally). Only three species were heard in large choruses (*P. crucifer*, *P. feriarum*, and *H. versicolor*), while the remaining species were heard in groups of less than 10 individuals. The most abundant species based on call surveys were *P. crucifer*, *P. feriarum*, and *H. versicolor,* followed by *Bufo americanus* and three ranid species. However, *B. americanus* adults were the most frequently encountered anurans during road cruising surveys and the second-most captured anurans in drift fence surveys (Table 1). Not only did anuran call surveys detect species that were missed by other sampling methods, but this was the only technique that provided wide-ranging distribution data for each species because most wetlands throughout a large area could be surveyed in one night. Notably, when coupled with incidental call observations, call surveys provided valuable information on the time and duration of calling periods for many species (Fig. 2).

Nighttime Road Surveys - Road surveys were conducted at both facilities on six separate occasions resulting in the detection of 98 individuals representing six anuran (81.6% of captures) and three salamander species (18.4% of captures) (Table 1). No reptiles were encountered during these surveys. A total of 176 km was traveled including road sections traveled repeatedly during the same session. This was the only technique to detect *Rana sylvatica* at the New River Facility (the breeding site was later determined to be a well-hidden vernal pond). Road cruising provided valuable insight to the location of unknown amphibian breeding sites and the technique was effective at collecting large numbers of some species (notably *B. americanus* and *Ambystoma maculatum*).

Cover Boards - Cover board arrays (n = 6) were placed in nine different sites and checked from June 1997 to November 1998. A total of 14 individuals of four snake and two salamander species was detected (Table 1). Snakes comprised 90% of all captures with five individuals being recaptured one or more times. All species detected using cover boards were also detected using other survey techniques. Cover board arrays were ineffective at detecting reptiles for most of the year: 90% of all captures took place in May and June 1998. No captures were made in 1997 and, consequently, three of the arrays were relocated during the winter. Almost all of the collections were made in either pine-grassland edge (*Thamnophis sirtalis* captured exclusively) or wetland marsh, whereas no species was detected in arrays placed in deciduous woods, the calcareous fen, or pine plantation interior. Cover boards were effective for collecting snakes and increased the total number collected by roughly 40% more than that of time-constrained surveys and drift fence/funnel trap arrays combined. However, considering the cost and time involvement in constructing the cover boards, and the numerous times arrays were checked without results, this technique was somewhat unsuccessful. Contrary to our results, Fitch (1992) found the use of cover boards (corrugated metal or wood) to be more successful than funnel traps or random encounters, with cover boards accounting for 68% of total captures and five species (31%) captured exclusively. However, unlike our survey, his study employed 300 cover boards with 25 to 100 per array, and specifically targeted snakes. Based on the results obtained during our survey and observations by Fitch (1992), we suggest using this technique in the situations (1) when time-constrained surveys are limited or absent, (2) with a large number of cover boards and in large arrays, and (3) with monitoring being concentrated during the vernal period

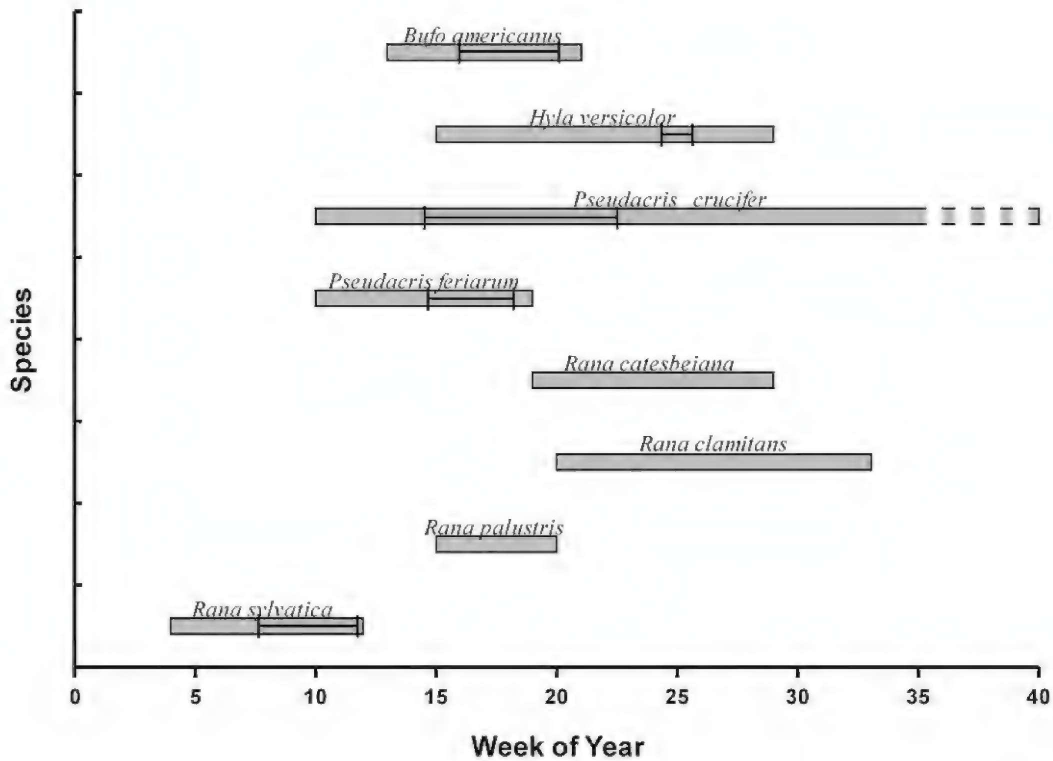

Fig. 2. Duration of incidental and survey calling periods for eight anuran species at RAAP, 1997 and 1998 combined. Brackets indicate large chorus observations; broken bars represent sporadic calling.

when reptiles and amphibians are most active and time of day when they are most likely to seek shelter.

Dip Net Surveys - Dip net surveys were conducted on a limited basis from January to July on seven occasions at four sites. A total of 170 larvae, mostly tadpoles, and two adults were collected, representing four anuran and three salamander species. It is notable that this was the first method to verify the presence of *Rana clamitans*, *R. sylvatica*, *P. feriarum*, *Ambystoma jeffersonianum*, *A. maculatum*, and *Notophthalmus viridescens*, although no species was exclusively detected using this technique.

Hoop and Basking Traps - Hoop traps were set overnight a total of six times and the basking trap was set in the morning and collected in the afternoon on five occasions, resulting in the capture of two species (*Chelydra serpentina* and *Pseudemys concinna)*. These two methods were found to not be feasible at RAAP because of security-limited access by land to the New River. Furthermore, hoop traps required at least two persons to be installed and collected in a timely manner, further restricting their use. Thus, this technique was abandoned after a few attempts. Use of a basking trap was the only successful method for capturing *P. concinna*, although the species may have been captured using hoop traps had they been applied more extensively. We also noted that basking turtles failed to return after repeated trap attempts at the same basking log, which would have required numerous trap relocations for effectiveness. These two techniques probably would have been much more successful if river access by boat had been a possibility, or if unlimited access to the shoreline had been available.

Species Richness and Relative Abundance

Deciduous Woods and Woodlots – Fifteen species were detected in deciduous woods during time-constrained surveys and from array captures (Table 2). Six salamander species (*Plethodon cinereus*, *P. glutinosus*, *P. wehrlei*, *Desmognathus fuscus*, *Eurycea cirrigera*, and *Notophthalmus viridescens*) accounted for 60% of all records, four anuran species (*Bufo americanus*, *Pseudacris crucifer*, *Hyla versicolor*, and *Rana sylvatica*) accounted for 28%, *Terrapene carolina* accounted for 3%, three snake species (*Elaphe alleghaniensis*, *Thamnophis sirtalis*, and *Coluber constrictor*) accounted for 3%, and *Sceloporus undulatus* (only along edges) accounted for 6%. Abundance from array captures was lower on average

Table 2. Relative abundance (CPUE) and species richness (SR) for broad category habitat types at RAAP, both years combined. CPUE is based on average number of captures per hour for time-constrained surveys and average number of captures per array night for drift fence arrays.

	Deciduous Woods			Pine Plantation			Grassland/ Old Field			Limestone Talus			Wetland			Riparian		
	n	CPUE	SR	*n*	CPUE	SR	*n*	CPUE	SR	*n*	CPUE	SR	*n*	CPUE	SR	*n*	CPUE	SR
Time-constrained searches	7	7.68	10	4	0.17	1	8	1.99	4	3	1.96	5	3	9.18	9	11	10.28	10
Drift fence arrays	4	0.55	11	2	0.46	4	2	0.05	5	--	--	--	3	2.8	13	--	--	--

than expected because of very few captures at Drift Fence (DF) 10 (CPUE = 0.06), located in second-growth deciduous woods with a poorly developed litter layer. DF 9, located in a large area of mature calcareous forest, had the highest CPUE (1.3) of any array in uplands, and is probably more indicative of species richness and abundance in other mature deciduous stands at RAAP.

Pine Plantation – Only five species were detected in pine plantation habitat. Based on time-constrained surveys and array captures (Table 2), *P. cinereus* accounted for 90% of the total captures, two anuran species (*P. crucifer* and *B. americanus*) accounted for 8%, and *T. carolina* and *Carphophis amoenus* accounted for 1% each. Abundance in pine plantations was higher than expected because of large numbers of *P. cinereus* captured at DF 2, New River Facility, and if excluded from abundance estimations CPUE dropped from 0.46 to 0.047. Only one individual of one snake species, *C. amoenus,* was found during visual searches in pine plantations, although a great deal of suitable habitat was thought to be present for lizards and snakes. Also, *T. sirtalis* was found beneath cover boards along the edge of pine habitat and grassland.

Grassland and Old Field – Eight species were detected in grassland and old field habitat. Based on time-constrained surveys and array captures (Table 2), four snake species (*E. alleghaniensis*, *Lampropeltis triangulum*, *T. sirtalis*, and *C. constrictor*) accounted for 78% of all captures, two anuran species (*P. feriarum* and *B. americanus*) accounted for 9%, and two salamander species (*Eurycea longicauda*, *E. cirrigera)* accounted for 13%. Turtles were not represented in the survey results, but *T. carolina* was observed incidentally on occasion in grassland. Notably, three streamside amphibian species (*E. longicauda*, *E. cirrigera*, and *P. feriarum*) were captured at DF 1 (located near a perennial stream). Species of *Eurycea* are known to migrate relatively long distances from riparian areas (MacCulloch & Bider, 1975), and based on our road cruising surveys, *P. feriarum* is possibly far-ranging from breeding sites in its foraging distribution. In the case of the New River Facility grasslands, which were historically forested and where riparian and lacustrine habitat are evenly interspersed throughout, it is fair to say that *P. feriarum* and the *Eurycea* species, along with *B. americanus* and possibly *Ambystoma jeffersonianum*, have maintained vibrant populations that disperse well away from the immediate aquatic zones and therefore should be considered grassland associates as well as wetland and/or riparian associates.

Limestone Talus – Five species were detected in sun-exposed limestone talus associated with road cuts and the quarry at the New River Facility (Table 2). These areas were dominated by reptiles with the exception of *B. americanus* and *P. wehrlei*, both found in slightly moist soil beneath talus. Based on time-constrained surveys, *T. sirtalis* and *Diadophis punctatus* accounted for 26% of total captures, *S. undulatus* 16%, *B. americanus* 5%, and *P. wehrlei* 53%. The two amphibians were only found in the talus areas of the TNT area, Main Facility.

Riparian – Nine species were detected in riparian areas and the New River (Table 2). Based on time-constrained surveys, five salamander species (*D. fuscus*, *D. quadramaculatus, E. cirrigera, E. longicauda*, and *Pseudotriton ruber*) accounted for 86% of all captures, *B. americanus* 2%, *Pseudemys concinna* 2%, and *Nerodia sipedon* and *Regina septemvittata* 10%. *Chelydra serpentina* also occurs in riparian areas but was only observed incidentally or captured in hoop traps.

Wetlands - Sixteen species were detected in perennial and ephemeral wetlands during time-constrained surveys and array captures (Table 2). Six salamander species (*A. jeffersonianum*, *A. maculatum*, *P. cinereus*, *E. cirrigera*, *E. longicauda*, and *N.*

viridescens) accounted for 23% of the total captures, seven anuran species (*B. americanus*, *P. feriarum*, *P. crucifer*, *H. versicolor*, *Rana catesbeiana*, *R. clamitans*, and *R. sylvatica*) 74%, *C. serpentina* and *Chrysemys picta* 2%, and *R. septemvittata* <1%. *Pseudacris feriarum* was abundant in wetlands of the New River Facility but was not collected in any of the wetland drift fence arrays, and *N. sipedon* was observed incidentally and beneath coverboards. Array captures of metamorphs and postmetamorphs accounted for 71% of anurans, but only 13% of salamanders.

The combined results of time-constrained searches and drift fence arrays (Table 2) suggest that average abundance and species richness is generally greater in wetland and riparian areas, moderate to high in deciduous woods and woodlots, and low in grasslands and pine plantations. However, these results should be viewed with caution because of noteworthy sample biases. For instance, Heyer et al. (1994) discouraged making relative abundance comparisons between habitat types when using time-constrained searches, since not all habitat types can be sampled with equal success. Furthermore, our search efforts were unequal among habitat types, as in the case of pine plantation where surveys were abandoned after several search sessions resulted in only one observation. Instead, most of our efforts were directed towards habitat types with the greatest likelihood of yielding additional species, and this likely has biased species richness estimates in favor of these areas. Yet another bias associated with time-constrained surveys was the inclusion of aquatic areas where species tend to be concentrated and were found with ease, resulting in the potential overestimation of abundance and species richness in wetlands and streams when compared to terrestrial environments. Finally, drift fence arrays constructed around ponds were configured to intercept animals moving toward/away from centralized breeding sites, in contrast to arrays in other habitat types that were configured to detect more randomized movement. Thus, our abundance and diversity estimates using these techniques are not wholly comparable between habitat types and should only be applied as baseline data in support of land management decisions and subsequent inventories.

Species Accounts

Reptile and amphibian species inventoried at RAAP in 1997 and 1998 are listed and described below. Taxonomic nomenclature, common names, and order of reference are based on species listings by Mitchell & Reay (1999). Detailed locality information for each species at RAAP is provided in VDGIF (1999).

Frogs and Toads

Bufo americanus Holbrook - American Toad

American Toads were detected at both facilities in both counties. This species occurred throughout the study area in almost all habitat types encountered including permanent and vernal ponds, drainage ditches, stream and river margins, upland and bottomland deciduous woods, and pine plantations. Calling (Fig. 2), mating, and oviposition were observed at permanent and vernal ponds from late March to late May. Our earliest records for first-year individuals captured in pitfalls was early July for both years. Many adults possessed morphological characteristics of *B. fowleri*, namely the presence of more than three warts within dark patches of the dorsum. This may suggest some degree of hybridization between the two species; however, this was the only identification characteristic of *B. fowleri* observed on collected individuals (Collins & Conant, 1998; Martof et al., 1980). *Bufo fowleri* was not heard calling at breeding sites in 1997 or 1998, and we could not detect any variation of *B. americanus* calls that would suggest hybridization between the two species (Zweifel, 1968). Mitchell & Reay (1999) and Tobey (1985) plotted records in Montgomery and Pulaski counties for *B. fowleri* in the vicinity of RAAP. However, based on audio surveys and absence of strong morphological characters, *B. fowleri* does not occur at RAAP, and we suggest caution should be taken when identifying this species in the New River Valley area based on dorsal markings alone.

Hyla versicolor LeConte - Gray Treefrog

Gray Treefrogs were detected at both facilities in both counties. Breeding sites were drainage ditches and ponds in pine-dominated woods. Calling by males was sporadic, occurring between mid-May through late July (Fig. 2), and often at forest edges far from water. A large chorus was heard on 10 June 1998 at a vernal pond surrounded by pine plantations at the New River Facility. The most notable characteristic of this species at RAAP is its apparent affinity for pine.

Pseudacris crucifer (Wied-Neuwied) - Spring Peeper

Spring Peepers occur at both facilities in both counties. Habitat associations included deciduous woods and grasslands near streams, pine plantations near ponds or wetlands, margins of permanent ponds, vernal pools, marshes, and drainage ditches. In both years, large breeding choruses began in mid-March and continued through mid- to late May; smaller choruses

of fewer than 10 individuals continued through mid-September (Fig. 2). Following choruses, sporadic calling was heard until early November, often far from water. In 1998, metamorphs and postmetamorphs were captured in pitfalls from early June to early July.

Pseudacris feriarum (Baird)- Southeastern Chorus Frog

This species is abundant at the New River Facility and tends to be concentrated in the northern portion of the plant, but it does not occur at the Main Facility. Habitat associations included grasslands near streams, vegetated drainage ditches and pond shallows, vernal ponds in grassland and pine plantation, and a ponded sinkhole in deciduous woods. In 1998, calling by males was from early March to early May, with the largest choruses occurring in mid- to late March (Fig. 2). According to Mitchell & Reay (1999), this represents a distribution record for this species in Pulaski County, although Tobey (1985) reported several records throughout the county.

Rana catesbeiana Shaw - American Bullfrog

Bullfrogs occur at both facilities in both counties. Habitat associations of adults and tadpoles were along margins of permanent and temporary ponds, wastewater lagoons, drainage ditches, and stream pools. Observations occurred from March to September; calling by males was recorded from mid-May to mid-June (Fig. 2).

Rana clamitans Rafinesque - Green Frog

Green Frogs occur at both facilities in both counties. Calling males were heard from mid-May to early July (Fig. 2). Habitat associations of adults and tadpoles were similar to those of bullfrogs. Both of these species tend to be most abundant in eutrophic aquatic environments at RAAP.

Rana palustris LeConte - Pickerel Frog

Pickerel Frogs were not observed at RAAP, but were detected by calling males heard incidentally during the day. One male was calling on 21 May 1997 along the shore of the New River at the Main Facility in Pulaski County. Three calling males were heard in mid- and late April at a fish pond at the Main Facility in Montgomery County. This is perhaps the least abundant and distributed anuran species at RAAP.

Rana sylvatica LeConte - Wood Frog

Wood Frogs occur at both facilities in both counties, although only one population was found at the New River Facility. Breeding habitats were vernal ponds in deciduous woods, pine plantation, old fields, and pastureland. However, the species is not obligated to breeding in temporary waters: a permanently inundated drainage ditch was used as a breeding site and one egg mass was found in a shallow region of a permanent fish pond. Adult males called from late January through late March (Fig. 2). Egg masses and mating were observed as early as 20 February in 1998. Metamorphs and postmetamorphs were collected at drift fences beginning in late June and tapering off in early July.

Salamanders

Ambystoma jeffersonianum (Green) - Jefferson Salamander

This species occurs at both facilities in both counties. Habitat associations are vernal ponds in pine plantation, pastureland, and deciduous woods, but breeding was not restricted to temporary ponds or forested habitat: adults were collected in pitfalls at a permanent pond in grassland approximately 150 m from the nearest wooded area. Egg masses and larvae were also collected along the margins of a permanent fish pond, a drainage ditch, and a concrete spring basin vegetated by cattail (*Typha latifolia*). In 1998, migration to breeding sites began in mid-February and recently transformed juveniles began dispersing by mid-June. Adults were collected at breeding sites no later than June 23 with the exception of three individuals captured in pitfalls in October 1998. Larvae collected at the New River Facility and raised in captivity were observed to feed on the larvae of *B. americanus, R. sylvatica, A. maculatum,* and other *A. jeffersonianum*. CSG has observed larval cannibalism in this species at a breeding pond less than 3.5 km from the Main Facility in Whitethorne, Montgomery County, and similar behavior has been reported by Petranka (1998).

Ambystoma maculatum (Shaw) - Spotted Salamander

Spotted Salamanders were detected only at the Main Facility in Montgomery County in March and April 1998. Habitat associations were a vernal pond and a permanent fish pond in deciduous woods, and a

perennial drainage ditch. Three adults were collected at a breeding pond on 9 March 1998; 13 adults were captured on 18 March 1998 while dispersing from their breeding site towards uplands. In 1998, egg masses were observed as late as 21 April, and a newly hatched larva (20 mm TL) was collected as late as 25 April. Larvae kept in captivity were eaten by *A. jeffersonianum,* but did not exhibit cannibalism.

Desmognathus fuscus (Green) - Northern Dusky Salamander

Dusky salamanders occur throughout both facilities where they were found beneath flat rocks in perennial and intermittent streams (usually in areas moist to saturated but not inundated) and beneath logs on sand and mud bars of small streams. Specimens were also found in crevices of steep stream banks at headcuts and beneath cover objects in vegetated wetlands. Some specimens were collected in pitfalls up to 5 m from an active stream. Larvae were found beneath rocks along stream margins and in leaf packs. Dorsal patterns were highly variable, and some individuals lacked pigmentation on the venter. Of 12 individuals sampled, half had a tail length $\geq$ 50% total length (TL) and showed sparse or no mottling on the venter. These characters made it difficult to differentiate between *D. fuscus* and *D. monticola* (Conant & Collins, 1998). Two adults similar in appearance to *D. monticola* were observed and determined to be *D. fuscus* based on head shape and dorsal markings (J.C. Mitchell, pers. comm.). No *D. monticola* were found at RAAP during the study.

Desmognathus quadramaculatus (Holbrook) - Black-bellied Salamander

Black-bellied Salamanders occur at the Main Facility in Montgomery County. Distribution is limited to one unnamed tributary to the New River at the easternmost portion of the facility and the three tributaries feeding Stroubles Creek. Black-bellied salamanders were found beneath flat rocks in rocky, shaded streams with moderate to fast moving water, usually in inundated regions or in the immediate streamside splash zone. Adults were seen foraging on large rocks at night and larvae were found during the day beneath rocks along stream margins.

Eurycea cirrigera (Green) - Southern Two-lined Salamander

Two-lined salamanders are abundant throughout both facilities. This species was found beneath cover objects in perennial streams (including New River), intermittent streams, springheads, pond margins, bottomland hardwood forest, and wetland marshes. Several adults were collected in pitfall traps located 25 m from the New River. Larvae were found beneath rocks during day or fully exposed at night in pools and shallows of streams and springs, often in association with larval *E. longicauda* and *Pseudotriton ruber*. Some larvae inhabiting karst springheads within grasslands of the New River Facility reach sizes prior to metamorphosis that potentially suggest a three-year larval period. For instance, one larva collected from a springhead on 30 March 1997 measured 33 mm SVL and 74 mm TL, which is at the upper size range of 13 metamorphosed specimens collected; transformation occurred after two weeks in captivity. Length of larval period is generally longer in northern than in southern populations of the closely related northern two-lined salamander, *E. bislineata* (Petranka, 1998). Hudson (1955) reported the maximum SVL of second-year larvae in Pennsylvania as 27.0 mm; SVL of third-year larvae averaged 29.6 mm. Larvae in Canada may reach a TL of >70 mm with some individuals overwintering into a third year (Petranka, 1998). Studies by Bruce (1986, 1988) on age of metamorphosis in North Carolina populations identified a one- or two-year larval period and maximum SVL of ca. 25 mm. However, Bruce (1982b) also reported SVL of second year larvae at Santeetlah Creek, North Carolina to average 31.8 mm, and Wood (1951) encountered three "year-old" individuals with SVL's of 32 mm in the Virginia Coastal Plain. Bruce (1982a) also noted that premetamorphs in a seepage-fed pond were significantly larger than those in a mountain stream. CSG has observed *E. cirrigera* larvae in streams in several counties in the New River Valley but has not encountered any comparable in size to this specimen. The larger larvae of the New River Facility are most likely at the upper extent of the size distribution for second-year individuals, but it is also possible that some individuals overwinter twice and metamorphose in the third year. To our knowledge, length of larval period or size at metamorphosis has not been closely studied for this species in the Virginia mountains.

Eurycea longicauda (Green) - Long-tailed Salamander

Long-tailed Salamanders occur at both facilities and were found in streams beneath rocks and cover objects along pond, spring, and stream margins. This species appears to be closely associated with the karst spring and pond system at the New River Facility, where all but one of the observations were in close proximity to active springs. Larvae were found at the New River Facility exposed at night in spring boxes and a spring

spillway. Larvae, but no adults, were found at the Main Facility in one of the unnamed tributaries to Stroubles Creek.

Notophthalmus viridescens (Rafinesque) - Red-spotted Newt

Newts were only found at the Main Facility in Montgomery County. Aquatic adults and larvae were collected in a perennial drainage ditch, and adults were also observed along the edge of a man-made fishing pond. Efts were found beneath rotting logs in deciduous woods and in pitfalls around a vernal pond in deciduous woods. Apparently, this species has not colonized the wildlife impoundments of the New River Facility.

Plethodon cinereus (Green) - Red-backed Salamander

Red-backed Salamanders (both color phases) occur at both facilities where they inhabit uplands of mature deciduous woods, mixed deciduous-pine woods, or pine plantations, with 72% of the total individuals counted occurring in mature pine plantations of the New River Facility. Observations occurred from February to December. Interestingly, pine plantations at the Main Facility do not support a population of *P. cinereus*, and this may be due to differences in previous land use and/or moisture regime.

Plethodon glutinosus (Green) - Northern Slimy Salamander

Slimy salamanders occur at both facilities and were found beneath large rocks or logs in mature deciduous woods of upland slopes and in association with *P. cinereus* and *P. wehrlei*. However, this species is much less abundant than its congeners.

Plethodon wehrlei Fowler and Dunn - Wehrle's Salamander

Wehrle's Salamanders were found from March to November at the Main Facility, Montgomery County. Habitat requirements were closely tied to the presence of limestone talus and regions of forested limestone sinks. Most individuals were collected in upland slopes of mature deciduous woods where talus is abundant. However, nine subadults and one adult were found on slightly moist soil beneath sun-exposed talus up to 30 m from deciduous woods; another adult was found in talus beneath a sun-exposed cover board located approximately 50 m from woods. None was found at these same locations when soils became entirely dry. Although it is unusual for *Plethodon* species to inhabit relatively dry microhabitats, this species seems to be considerably more tolerant of such conditions than are other *Plethodon* species at RAAP. Pauley (1978) found *P. wehrlei* more abundant than *P. cinereus* in drier microhabitats exhibiting higher temperature and greater wind exposure.

Pseudotriton ruber (Latreille) - Red Salamander

Red Salamanders were observed only at the New River Facility. Adults and larvae were found beneath rocks at springheads and in stream riffles. Most 1-2 year larvae were observed foraging in pools at night, and a few were collected incidentally with dip nets during aquatic invertebrate surveys. Larger larvae (>70 mm TL) that appeared to be nearing metamorphosis were found beneath rocks submerged in shallow water. Adults were also observed foraging on humid nights in the vicinity of springheads, where as many as nine individuals were seen at one time in an area approximately 4 m^2. On 19 March, 1998, a leucistic adult *P. ruber* was found foraging near a springhead at the New River Facility (KU CT 11720-21). This was the first documented occurrence of albinism in the genus *Pseudotriton* (Garriock, 2000). Red Salamanders were not detected at the Main Facility although suitable habitat exists there, especially in the more shaded tributaries of Stroubles Creek.

Turtles

Chelydra serpentina (Linnaeus) - Snapping Turtle

Snapping Turtles occur in wastewater lagoons, ponds, perennial streams, vegetated wetland ditches, and the New River. Although most individuals were observed basking in ponds at the water surface, on 7 July 1997 one adult was observed basking on a log along the New River shoreline, and on 17 April 1998 two adults were observed simultaneously basking above the water surface in a red cedar (*Juniperus virginiana*) snag in the center of a man-made pond (Roble & Garriock, 1998). Aerial basking is unusual in southern populations (Palmer & Braswell, 1995), and rarely does more than one Snapping Turtle utilize the same basking site (Ernst et al., 1994).

Chrysemys picta (Schneider) - Painted Turtle

Painted Turtles were observed at both facilities while swimming or basking in drainage ditches, permanent and temporary ponds, wastewater lagoons, and the New River. Observations occurred from April to September. On 13 May 1997, two farm ponds used

for cattle watering at the New River Facility were found to contain Painted Turtle hatchlings. Both ponds were approximately 15 m in diameter and shallow with a mud substrate. The number of hatchlings basking (with heads emerged) was counted to be 25 in one pond and 45 in the other. Two of the hatchlings were collected, both with a CL of 27 mm and plastron length of 31 mm. The ponds were completely dry two weeks later, and presumably the juveniles had burrowed into the pond bottom and/or dispersed through pastureland in search of other water sources.

Pseudemys concinna (LeConte) - River Cooter

River Cooters were observed along the entire stretch of the New River through RAAP, but were most abundant in 1997 in a rocky section of the river (approximately 1.1 km east of the New River Bridge). River Cooters were observed basking on emerged rocks and logs throughout the warm season. On 21 August 1997, as many as 11 adults were counted basking in an approximately 50 m stretch of the river (river width = 180 to 215 m). On multiple occasions as many as seven turtles were observed basking on one log at the same time, and on several occasions two were observed basking on the same rock. Notably, upon release of water from the Claytor Lake Dam, rising water levels would force turtles basking on rocks to relocate to logs along the shoreline, suggesting the preferred basking sites occur on rocks some distance from the shoreline. On at least two occasions cooters were displaced from rocks by conspecifics, suggesting competition for basking sites. However, Mitchell (1994) reported that aggressive behavior has not been observed in this species. Unfortunately, installation of a wastewater effluent diffuser beneath the riverbed during the winter of 1997 resulted in the removal of nearly all emergent basking rocks at the bridge site. Consequently, river cooters were not observed in this area in 1998. This is a disjunct population in the New River of Virginia and was discovered only recently. In 1987, Buhlmann (1989) documented the Radford population as being the first to occur in the New River in Virginia, although several years earlier Seidel (1982) reported a New River population in Virginia, most likely in the vicinity of the Bluestone Reservoir dam. Based on bone fragments of *P. concinna* excavated at archaeological sites within the Main Facility, the species likely occurred there prior to the 13th century (Barber & Tolley, 2002).

Terrapene carolina (Linnaeus) - Eastern Box Turtle

Box turtles occur at both facilities and were found in deciduous forests and woodlots, pine plantations, grasslands, old fields, rocky slopes, near streams, and in shallow, ephemeral pools. Observations of active adults occurred from April to October. A millipede (Polydesmida) and a caterpillar (Lepidoptera) were observed being eaten by adult females in June 1997. On 19 November 1997, while clearing leaf litter for pitfall installation in a deciduous woodlot, an adult box turtle (sex undetermined) was found in a hibernaculum. A downward angled ditch had been excavated until the top of the carapace was even with the soil surface and approximately 8 cm of leaf litter covered the partially exposed carapace. The turtle was left undisturbed and the location marked and monitored during the spring; the burrow was vacated during the second week of April 1998.

<u>Lizards</u>

Sceloporus undulatus (Green) - Fence Lizard

Fence Lizards occur at the Main Facility in Montgomery County and are restricted to sun-exposed, xeric, rocky cliffs and buildings adjacent to upland deciduous woods. Two separate populations were identified: one inhabits limestone talus cliffs adjacent to calcareous woods in the southwestern portion of the facility, and the other occurs in rocky areas of the sandstone/shale – oak association of the southeastern portion of the facility. We cannot readily explain the apparent absence of this species from the remainder of RAAP, especially the New River Facility, where sun-exposed talus, rock piles, log piles, and old buildings are abundant. One explanation for this may be the lack of suitable microhabitat adjacent to mature deciduous forest, an association that seems to be correlated with the two populations at the Main Facility. Also, based on distribution records in Virginia (Mitchell & Reay, 1999), Fence Lizards are not well documented in the New River Valley. Records are lacking for several nearby counties, including Floyd, Giles, Pulaski, and Grayson, whereas Carroll and Wythe counties contain only one record each (but see Gibson & White, 2003).

<u>Snakes</u>

Agkistrodon contortrix Palisot de Beauvois – Copperhead

One specimen was found at RAAP in Montgomery County (29 October 1997), the result of a road kill at the Main Facility. Based on personal accounts and photographs provided by RAAP and security personnel, Copperheads occur at both facilities, especially in the

forested, sandstone/shale areas in the westernmost portion of the Main Facility where our specimen was found. Time-constrained surveys in this region were unsuccessful in finding the species, although they are apparently common there.

Carphophis amoenus (Say) - Eastern Wormsnake

The only wormsnakes observed were two found at the Main Facility in Pulaski County. One was encountered during a time-constrained survey in a rotting log at the edge of a pine plantation, and the other was collected in a pitfall array in an old field. This is one of only two snake species detected in pine plantations of the Main Facility (the other species being *Thamnophis sirtalis*).

Coluber constrictor Linnaeus - Northern Black Racer

Black racers were found only at the New River Facility along the edges of deciduous woods and in open areas beneath limestone talus. One juvenile (TL = 355.6 mm) was collected in a drift fence funnel trap on 8 October 1997 at the edge of deciduous woods.

Diadophis punctatus (Linnaeus) - Ring-necked Snake

Ring-necked Snakes were found at both facilities. Two specimens were found during time-constrained surveys beneath thin limestone talus in sun-exposed areas; a third individual was found beneath a cover board over muddy substrate in a cattail marsh.

Elaphe alleghaniensis (Holbrook) - Eastern Ratsnake

Ratsnakes were found throughout both facilities. Adults were found basking or hidden beneath cover objects in deciduous woods and woodlots, woodland edges, wetland margins, grasslands, debris piles, and buildings. Ratsnakes occur abundantly in the walls and rafters of wood frame storage buildings at both facilities.

Lampropeltis triangulum (Lacepède) - Eastern Milksnake

Milksnakes were observed at both facilities beneath cover objects near storage buildings or in grasslands. Two juveniles were found incidentally crossing roads within grasslands and deciduous woods. Patterns were of the blotched type of red or brown coloration (Mitchell, 1994).

Nerodia sipedon (Linnaeus) - Northern Watersnake

Watersnakes occur at both facilities where adults and juveniles were found either basking in trees or on large rocks of riparian areas, or beneath large flat rocks of rocky stream bars. Several individuals were found beneath cover boards in a cattail marsh, and one adult was collected from a small perennial stream after being electro-shocked during a fish survey. This species is abundant at RAAP and likely occurs near all permanent water sources at either facility.

Regina septemvittata (Say) - Queen Snake

Queen Snakes were detected only at the Main Facility in Montgomery County within riparian areas of Strounbles Creek and at a drainage ditch. Adults were found either beneath rocks at stream edges or basking in streamside shrubs. This species undoubtedly occurs in riparian areas of the New River as well, and although it was not detected there, may occur within stream or wetland habitat at the New River Facility.

Thamnophis sirtalis (Linnaeus) - Eastern Gartersnake

Gartersnakes occur throughout both facilities. This species was found as early as February basking or beneath cover objects in practically all habitat types at RAAP, including limestone talus, pine plantation edges, and wetlands. This species and the Eastern Ratsnake are likely the most abundant and widely distributed snakes at RAAP.

Undetected Species

Several species were expected or thought likely to occur at RAAP based on documented distribution, local sightings, and habitat types on the base. These are briefly discussed below.

Bufo fowleri Hinckley - Fowler's Toad

There are seven confirmed records for this species in Pulaski and Montgomery counties (Tobey, 1985; Mitchell & Reay, 1999), including several in the vicinity of RAAP. However, based on two consecutive years of anuran call data and the lack of strong *B. fowleri* morphological characteristics (lack of dark markings on the chest and enlarged warts on the tibia) on any of the *Bufo* individuals observed, we do not believe this species occurs at the base, or if it does is extremely rare. According to Mitchell & Reay (1999),

B. fowleri prefers sandy soils in Virginia, limiting its distribution west of the Coastal Plain. At RAAP this type of habitat would be confined to alluvial areas along Stroubles Creek and the New River. More information concerning anuran call data is needed to properly assess the distribution of *B. fowleri* and the complexity of *Bufo* hybridization in the New River Valley.

Scaphiopus holbrookii (Harlan) – Eastern Spadefoot

Very few mountain records exist for this species in Virginia (Tobey, 1985; Mitchell & Buhlmann, 1999; Mitchell & Reay, 1999; Gibson, 2002), but two are within a few miles of RAAP. If the Eastern Spadefoot occurs at RAAP, it should have been detected during our nighttime road surveys or anuran call surveys because it is considered to have a very loud call (Green & Pauley, 1987) and to be an explosive breeder during heavy rains (Tobey, 1985). At RAAP, the species would most likely occur within the New River floodplain of the Main Facility where sandy, alluvial soils occur naturally, but soil disturbances in the way of pine plantations and industrial development have depleted much of this substrate type within the facility.

Ambystoma opacum (Gravenhorst) - Marbled Salamander

This species occurs primarily east of the Blue Ridge except for isolated records in Page, Rockbridge, Botetourt, Augusta (Mitchell & Reay, 1999), and Alleghany counties (Hoffman, 1985). It was also documented in Craig County about 64 km northeast of RAAP (Hayslett, 1994), and Tobey (1985) published a sight record (unconfirmed) near RAAP in Montgomery County. Recently, larvae identified as *A. opacum* were found in Wythe County (Gibson & White, 2003) and a subadult was reported from Scott County (Hobson & Roble, 2003). However, based on lack of documented evidence that *A. opacum* occurs in the New River Valley, and since most of the known vernal breeding sites at RAAP were intensively surveyed during the breeding and/or larval periods, we do not believe the species is likely to occur on the base.

Cryptobranchus alleganiensis (Daudin) – Hellbender

There are several documented occurrences of this species in the New River in the Radford area (Mitchell & Reay, 1999) and it was once considered to be abundant above the Little River dam just south of Radford (R. L. Hoffman, pers. comm.). This species most likely occurs in the New River within the confines of RAAP given that areas of suitable habitat are common, but because of its secretive and nocturnal nature, little emphasis was placed on detecting it during our surveys. We have heard of several undocumented Hellbender sightings in the Little and New rivers in Pulaski, Montgomery, and Floyd counties, and based on discussions with area fishermen, Hellbenders are still killed (when accidentally caught) because of misconceptions that they are poisonous or predators of game fish.

Necturus maculosus (Rafinesque) – Mudpuppy

Mudpuppies are not documented to occur in the New River drainage (Mitchell & Reay, 1999) except for one unconfirmed record in Pulaski County (Hoffman, 1984; Tobey, 1985) in a section of the New River that is now part of Claytor Lake. Unfortunately, the specimen was lost before Hoffman (1984) could confirm it as being *N. maculosus*. Although there is a remote chance the species occurs in the New River at RAAP, we did not attempt to find it during our surveys.

Desmognathus monticola Dunn – Seal Salamander

The Seal Salamander should occur at RAAP and may still be documented with additional surveys. It is unusual that this species was not found given the broad range of riparian habitat surveyed throughout much of the base. Based on distributional records (Tobey, 1985; Mitchell & Reay, 1999), *D. monticola* is abundant in the New River Valley, and is reported by Petranka (1998) to be most abundant at elevations below 1219 to 1372 m. The most likely place for this species to occur on the base is the easternmost tributary of Stroubles Creek (Geese Branch). However, *D. quadramaculatus* is abundant there and could have possibly excluded *D. monticola* from the stream channel (Petranka, 1998).

Eurycea lucifuga Rafinesque – Cave Salamander

Given that much of RAAP is underlain by limestone bedrock and with sinkholes being common, it seems very likely that the Cave Salamander would occur at RAAP. We explored on two occasions the only accessible (without excavation) cave opening found, but did not find the species. The Cave Salamander in Virginia occurs primarily in the Ridge and Valley region bordering West Virginia and in the extreme western counties of the state (Tobey, 1985; Mitchell & Reay, 1999); the nearest records occur only 8 km to the north of the Main Facility in bordering Giles County.

Gyrinophilus porphyriticus (Green) – Spring Salamander

Although this species occurs throughout southwestern Virginia, we were unsuccessful at finding adults or larvae. This is surprising given the suitability of the rocky, shaded streams feeding Stroubles Creek and the numerous springheads at the New River Facility. Further surveys in these two areas could yield the species, especially in Geese Branch and the unnamed perennial stream in the northeast quadrant of the Main Facility that drains directly into the New River.

Hemidactylium scutatum (Schlegel) – Four-toed Salamander

The Four-toed Salamander occurs in Montgomery County and neighboring Giles, Floyd, and Wythe counties (Tobey, 1985; Mitchell & Reay, 1999), but was not found at RAAP. Wet areas supporting sphagnum mats or bogs, the preferred breeding habitat for the species (Green & Pauley, 1987), were searched when encountered incidentally, but such areas were not significant in their occurrence at either facility.

Sternotherus odoratus (Latreille) – Eastern Musk Turtle

Confirmed records for this species occur along the New River up and downstream of RAAP (Mitchell & Reay, 1999) and they have been observed by S. Garriock and M. Pinder (VDGIF) in the New River approximately 8 km north of RAAP. We attempted on three separate occasions to find this species by snorkeling vegetated shallows of the New River, and no observations were made during a mussel survey of the New River in 1998. Based on nearby records it is reasonable to assume *S. odoratus* occurs at the Main Facility within the New River and possibly Stroubles Creek. Bone fragments have been found on the New River floodplain at the Main Facility (Barber & Tolly, 2002).

Eumeces fasciatus (Linnaeus) – Five-lined Skink

Skinks were not observed at RAAP even though excellent habitat (e.g., sun-exposed, rocky areas, concrete structures, open pine woods) is ubiquitous at both facilities. Mitchell & Reay (1999) reported sparse records in the mountain provinces with only one documented record in the New River Valley (Blacksburg area). This species has also been observed in the McCoy area (unconfirmed record) approximately 5 km north of RAAP, and in Giles and Floyd counties (Tobey, 1985; Garriock et al., 1996). This suggests that the species is more widespread in the New River Valley than indicated by Mitchell & Reay (1999), although populations appear to be fragmented in their distribution. We believe it is unlikely that *E. fasciatus* was missed at RAAP because the species tends to be easily found where it occurs.

Heterodon platirhinos Latreille – Eastern Hognose Snake

Records for this species are scattered and widespread in the mountains of Virginia including three confirmed records in Montgomery and Pulaski counties (Mitchell & Reay, 1999). We specifically sought this species on the dry sandstone/shale areas in the southeastern portion of the Main Facility without success. There was an undocumented account of this species in 1998 in the McCoy area and discussion with a maintenance worker revealed that "blowin vipers" were abundant in the agricultural areas of the New River Facility more than 20 years ago, but were often killed during mowing operations.

Opheodrys aestivus (Linnaeus) – Rough Greensnake

Based on documented localities, this species seems to be very uncommon in the New River Valley in Virginia, with only one record in central Wythe County (Mitchell & Reay, 1999) and two records in southern Carroll County (Tobey, 1985). It is documented to occur in Raleigh County, West Virginia (Green & Pauley, 1987), but the locality may not be within the New River Drainage Basin. An eastern Montgomery County record (Mitchell & Reay, 1999) occurs within the North Fork Roanoke River Drainage, and CSG has seen the species in Montgomery County crossing a road adjacent to the North Fork Roanoke River. We made specific attempts, without success, to find Rough Greensnakes during a few nighttime time-constrained surveys. This was done by shining a bright light upward into overhanging stream and pond margin vegetation and searching for ventral scale reflections.

Thamnophis sauritus (Linnaeus) – Eastern Ribbonsnake

This is another species that is poorly represented in the New River Valley and westward, although two vouchered (Mitchell & Reay, 1999) and three unvouchered (Tobey, 1985) records occur in the Valley surrounding RAAP (Carroll, Giles, Grayson, Montgomery, and Pulaski counties), and CSG has observed and photographed this species on a few occasions in or adjacent to wetlands in Floyd County

(Garriock et al., 1996). Nonetheless, given only a few confirmed records, the Eastern Ribbonsnake is likely uncommon and spotty in distribution in the New River Valley. Because of its affinity for wet areas, which are common at RAAP, we had hoped to find the species beneath cover boards placed in marshes and fens or in our pond-perimeter funnel traps.

CONCLUSION AND MANAGEMENT CONCERNS

Several areas harboring notable reptile and amphibian diversity occur within the confines of RAAP. These areas should be considered when making natural resource management decisions. Notable localities within the Main Facility are 1) the calcareous forest region west of the main entrance; 2) the calcareous and oak forest (including the pond and associated riparian areas of Stroubles Creek and its tributaries) in the southeast portion of the plant; 3) vernal ponds within the Stroubles Creek floodplain; and 4) drainage ditches within the New River floodplain. Bottomland hardwoods along the New River were not adequately sampled and require further surveys. The most notable areas within the New River Facility are 1) wildlife impoundments along with associated springheads and marshes; 2) the vernal pond located just northeast of the main entrance; 3) deciduous woodlots within the grassland-pine matrix; and 4) the calcareous forest of the Hazel Hollow area.

Potential threats to reptiles and amphibians of RAAP are primarily improper storage and disposal of toxic chemicals, draining or maintenance of existing wetlands, impacts to streams, clearcutting, and herbicide application in grasslands. There are few natural wetland systems remaining at the base; however, man-made systems such as the wildlife impoundments have created a considerable amount of good habitat, and should be kept active. There also exists potential for wetland restoration or creation within the New River floodplain at the Main Facility that, if undertaken, would significantly benefit biodiversity at the facility. Equally important are the isolated vernal pond systems that may not receive protection under current state and federal laws (Sections 401/404 of the 1997 Clean Water Act). These systems tend to be small and may seem insignificant, but they harbor a specialized, yet diminishing ecosystem still unknown to most people. Care should be taken in the management of the existing upland and bottomland hardwood systems that are currently in climax stages and contiguous over large areas, because these areas harbor much of plant and wildlife diversity on the base. Although we realize the importance of the hardwood component as a renewable natural resource commodity, deforestation of these areas would severely impact the facility's biological diversity. With regard to riparian buffers, much effort should go into protecting existing stream and vernal pond forest buffers, and addition of new hardwood buffers should be considered in mitigation opportunities if they arise. An especially worthy undertaking would be replacement of the New River pine buffer, when all or portions are harvested, with mesic bottomland hardwood species. Finally, creative management of grasslands that regulates and oversees mowing operations, cattle grazing, and herbicide application, yet still provides benefits to local game hunters and farmers, would likely have substantial positive effects on grassland floral and faunal biodiversity.

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LITERATURE CITED

Barber, M. B., & G. A. Tolly. 2002. Archaeology in a post-September 11 world: salvage work at 44PU72, Radford Army Ammunition Plant, Pulaski County, Virginia. Paper presented at the 69th Eastern States Archaeological Federation Conference, Mt. Laurel, New Jersey. 30 pp.

Bruce, R. C. 1982a. Larval periods and metamorphosis of two species of salamanders in the genus *Eurycea*. Copeia 1982: 117-127.

Bruce, R. C. 1982b. Egg-laying, larval periods and metamorphosis of *Eurycea bislineata* and *E. junaluska* at Santeetlah Creek, North Carolina. Copeia 1982: 755-762.

Bruce, R. C. 1986. Upstream and downstream movements of *Eurycea bislineata* and other salamanders in a Southern Appalachian stream. Herpetologica 42: 149-155.

Bruce, R. C. 1988. An ecological life table for the salamander *Eurycea wilderae*. Copeia 1988: 15-26.

Buhlmann, K. A. 1989. Geographic distribution: *Pseudemys concinna concinna*. Herpetological Review 20: 76.

Bury, R. B., & P. S. Corn. 1987. Evaluation of pitfall trapping in Northwestern forests: trap arrays with drift fences. Journal of Wildlife Management 51: 112-119.

Bury, R. B., & M. G. Raphael. 1983. Inventory methods for amphibians and reptiles. Pp. 416-419 *In* J. F. Bell & T. Atterbury (eds.), Renewable Resource Inventories for Monitoring Changes and Trends. Oregon State University, Corvallis, OR.

Campbell, H. W., & S. P. Christman. 1982. Field techniques for herpetofaunal community analysis. Pp. 193-200 *In* N. J. Scott, Jr. (ed.), Herpetological Communities. U. S. Department of the Interior, Fish and Wildlife Research Report 13.

Chase, C. 1998. Integrated natural resources management plan for Radford Army Ammunition Plant, Radford, Virginia (Draft). U.S. Department of Defense. 39 pp.

Conant, R., & J. T Collins. 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Third Edition. Houghton Mifflin Company, Boston, MA. 616 pp.

Dodd, C. K. 2001. North American Box Turtles: A Natural History. University of Oklahoma Press, Norman, OK. 231 pp.

Ernst, C. H., R. W. Barbour, & J. E. Lovich. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington, DC. 578 pp.

Fitch, H. S. 1992. Methods of sampling snake populations and their relative success. Herpetological Review 23: 17-19.

Garriock, S. 2000. Albinism: *Pseudotriton ruber ruber*. Herpetological Review 31: 39.

Garriock, S., M. Kirkendall, & S. Carter. 1996. Reptile and amphibian observations, Floyd Co., Virginia. Catesbeiana 16: 44-45.

Gibson, J. D. 2002. Herpetofaunal survey of Sherando Lake Recreation Area, Loves Run Pond Complex, Green Pond, and Humpback Rocks. Catesbeiana 22: 3-13.

Gibson, J. D., & J. White. 2003. Biological diversity of reptiles and amphibians in Big Survey Wildlife Management Area. Catesbeiana 23: 3-13.

Green, N. B., & T. K. Pauley. 1987. Amphibians and Reptiles in West Virginia. University of Pittsburgh Press, Pittsburgh, PA. 241 pp.

Greenberg, C. H., D. G. Neary, & L. H. Harris. 1994. A comparison of herpetofaunal sampling effectiveness of pitfall, single-ended, and double–ended funnel traps used with drift fences. Journal of Herpetology 28: 319-324.

Hayslett, M. S. 1994. Field notes: *Ambystoma opacum*. Catesbeiana 14: 42.

Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L.-A. C. Hayek, & M. S. Foster (eds.). 1994. Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press, Washington, DC. 364 pp.

Hobson, C. S., & S. M. Roble. 2003. Geographic distribution: *Ambystoma opacum* (Marbled Salamander). Herpetological Review 34: 160.

Hoffman, R. L. 1984. *Necturus maculosus* in the New River? Catesbeiana 4: 11.

Hoffman, R. L. 1985. The herpetofauna of Alleghany County, Virginia, Part 2. Class Amphibia. Catesbeiana 5: 3-13.

Hudson, R. G. 1955. Observations on the larvae of the salamander *Eurycea bislineata bislineata*. Herpetologica 2: 202-204.

Jones, K. B. 1981. Effects of grazing on lizard abundance and diversity in western Arizona. Southwestern Naturalist 26: 107-115.

Kremen, C., R. Colwell, T. L. Erwin, D. D. Murphy, R. F. Noss, & S. Muttulingam. 1993. Terrestrial arthropod assemblages: their use as indicators for biological inventory and monitoring programs. Conservation Biology 7: 796-808.

MacCulloch, R. D., & J. R. Bider. 1975. Phenology, migrations, circadian rhythm and the effect of precipitation on the activity of *Eurycea bislineata bislineata* in Québec. Herpetologica 31: 433-439.

Martof, B. S., W. M. Palmer, J. R. Bailey, & J. R. Harrison III. 1980. Amphibians and Reptiles of the Carolinas and Virginia. University of North Carolina Press, Chapel Hill, NC. 264 pp.

Mitchell, J. C. 1991. Amphibians and reptiles. Pp. 411-423 *In* K. Terwilliger (coord.), Virginia's Endangered Species. McDonald & Woodward Publishing Co., Blacksburg, VA.

Mitchell, J. C. 1994. The Reptiles of Virginia. Smithsonian Institution Press, Washington, DC. 352 pp.

Mitchell, J. C., & K. A. Buhlmann. 1999. Amphibians and reptiles of the Shenandoah Valley Sinkhole Pond System in Virginia. Banisteria 13: 129-142.

Mitchell, J. C., & K. K. Reay. 1999. Atlas of Amphibians and Reptiles in Virginia. Special Publication Number 1, Virginia Department of Game and Inland Fisheries, Richmond, VA. 122 pp.

Palmer, W. M., & A. L. Braswell. 1995. Reptiles of North Carolina. The University of North Carolina Press, Chapel Hill, NC. 412 pp.

Pauley, T. K. 1978. Moisture as a factor regulating habitat partitioning between two sympatric *Plethodon* (Amphibia, Urodela, Plethodontidae) species. Journal of Herpetology 12: 491-493.

Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, DC. 587 pp.

Roble, S. M. 2001. Natural heritage resources of Virginia: rare animal species. Natural Heritage Technical Report 01-16. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 33 pp.

Roble, S. M., & S. Garriock. 1998. Field notes: *Chelydra serpentina serpentina*. Catesbeiana 18: 53-54.

Seidel, M. E. 1982. The turtle *Pseudemys concinna* (Testudines: Emydidae) in the New River. Pp. 77-81 *In* W. E. Cox & C. K. Sullivan (eds.), Proceedings of the First New River Symposium, May 6-8, 1982, Beckley, WV. National Park Service, Glen Jean, WV.

Tobey, F. J. 1985. Virginia's Amphibians and Reptiles: A Distributional Survey. Virginia Herpetological Society, Purcellville, VA. 114 pp.

Virginia Department of Game and Inland Fisheries. 1999. Biological survey of the Radford Army Ammunition Plant (RAAP); including Threatened, Endangered, and Species of Concern. Richmond, VA. 85 pp.

Welsh, H. H., Jr. 1987. Monitoring herpetofauna in woodland habitats of northwestern California and southwestern Oregon: a comprehensive strategy. Pp. 203-213 *In* T. R. Plumb & N. H. Pillsbury (technical coord.), Proceedings of the Symposium on Multiple-use Management of California's Hardwood Resources. U.S. Department of Agriculture, Forest Service General Technical Report PSW-100.

Wood, J. T. 1951. Protective behavior and photic orientation of adult and larval two-lined salamanders *Eurycea bislineata cirrigera*. Virginia Journal of Science 122: 113-121.

Zweifel, R. G. 1968. Effects of temperature, body size, and hybridization on mating calls of toads, *Bufo a. americanus* and *Bufo woodhousii fowleri*. Copeia 1968: 269-284.

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Distribution of *Lythrum salicaria* L., Purple Loosestrife, in Western Virginia and Northeastern Tennessee

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ABSTRACT

Purple loosestrife (*Lythrum salicaria* L.) is an endemic species of Eurasia and since its introduction in the late 18th century has become a highly invasive weed in North America. This species reportedly displaces native wetland plant species by forming monocultures. The changes in number and size of purple loosestrife infestations at 51 sites in western Virginia and northeastern Tennessee were monitored over an 11-year period. All sites were along riverbanks or in shallow water along the Clinch, James, and Maury rivers. Only two sites could be considered wetlands. At the 43 sites not impacted by biological control agents or human activities, there was no change in purple loosestrife abundance at seven sites (16%), a decrease at 19 (44%), and an increase at 17 sites (40%). More than twice the number of sites that increased were frequently flooded open cobble bars. The flooding disturbance seems to make these areas more susceptible to invasion and persistent infestations. Purple loosestrife infestations responded similarly in all three rivers during the study. There was a significant difference in the change in density during the study between the two major habitat types. Cobble bar sites increased while riverbank sites decreased in density during the study. The presumed age of these infestations varied considerably and may have influenced the size of the infestations. Generally, large infestations were closer to the initial infestation and presumably older than those downstream. However, the most distant site from the initial infestation was one of the largest infestations. This suggests that the size of the infestation is influenced more by habitat suitability than age of the infestation. Seven species of rare plant populations that prefer a similar habitat as purple loosestrife have been recorded or grow in close proximity to the sites recorded in this study. Populations of water willow (*Justicia americana*), a valuable species in the riverine ecosystem, were susceptible to invasion by purple loosestrife. The threat of purple loosestrife to this species and rare plant species warrants continued monitoring throughout this study area.

Key words: purple loosestrife, *Lythrum salicaria*, distribution, invasive species, Virginia.

INTRODUCTION

Purple loosestrife (*Lythrum salicaria* L.) is considered native to Eurasia and occurs in the eastern hemisphere in Eurasia, northern Africa, and Australia (Hultén, 1971). It has a perennial rootstock that annually sends up 4 - 10 stems per root and grows to a height of two meters (Thompson et al., 1987). Dispersal is primarily through seed. Shamsi & Whitehead (1974) reported annual seed production of approximately 100,000. Other estimates range from 300,000 (Teale, 1982) to 2.7 million seeds annually (Thompson et al., 1987). Seeds may also remain viable for several years (Shamsi & Whitehead, 1974; Rawinski, 1982). Since the early 19th century purple loosestrife has become a major weed of wetlands in North America (Stuckey, 1980), infesting over 400,000 acres and displacing native wetland plant species (Thompson et al., 1987). Initial establishment of purple loosestrife is often associated with recently disturbed areas such as industrial, construction, waste, and dump areas (Stuckey, 1980). Water level reduction, and highway construction and maintenance also provide favorable conditions for establishment (Wilcox, 1989). Its efficient use of nutrients and energy (Nagel & Griffin, 2001) plus the absence of host-specific herbivores (Blossey & Notzold, 1995; Galatowitsch et al., 1999) may explain the competitive advantage of

purple loosestrife over native plant species in North America.

The introduction of purple loosestrife into North America began in the late 18th and early 19th centuries. Ballast such as sand and rock taken from the harbors of Europe where purple loosestrife was naturally growing was used on ships on their voyage to North America (Thompson et al., 1987). From these harbors purple loosestrife was able to spread inland by dispersal of seeds adhering to migrating birds and wildlife. Over the past two centuries, purple loosestrife has also been planted in cultivated gardens for herbal, aesthetic, and beekeeping purposes (Thompson et al., 1987). Its present distribution in North America extends from southern Canada south to the 36th parallel (Stuckey, 1980; National Agricultural Pest Information System, 2004).

Purple loosestrife was reported at Salt Sulfur Springs resort, Monroe County, West Virginia in 1885 (Stuckey, 1980). It was also reported in Indian Creek in Monroe County, and at Mercer Springs resort in Mercer County, West Virginia (McNeil, 1938). There were no records of establishment of purple loosestrife in Virginia prior to 1900, although it was reported in adjacent states near the border of Virginia. It was planted in fish ponds in Washington D. C. and in waste areas in Wilmington, North Carolina in the late 1800s (Stuckey, 1980). It was reported as rare in marshes in Watuga County, North Carolina (Radford et al., 1968). During the 19th century it was planted as a medicinal and ornamental at health resorts.

In Virginia, Capel (1993) reported purple loosestrife increasing from 15 counties in 1981 to 25 counties in 1992. The Atlas of Virginia Flora (Harvill et al., 1992) documented 24 counties with purple loosestrife; three of these counties (Scott, Wise, and Buchanan) are in southwestern Virginia.

Recognizing the limitations of mechanical and chemical control procedures, biological control was initiated and several insect species were extensively tested and approved for release in 1992 (Kok et al., 1992 a, b; Malecki et al., 1993; Blossey et al., 1994 a, b). Three natural enemies of purple loosestrife, *Galerucella calmariensis* L., *G. pusilla* Duftschmidt (Coleoptera: Chrysomeldiae), and *Hylobius transversovittatus* Goeze (Coleoptera: Curculionidae), were collected in Germany by the International Institute of Biological Control (CABI Bioscience) and releases began in 1992. Establishment of these biological control agents on purple loosestrife in Virginia was reported by McAvoy et al. (1997, 2002) and Kok et al. (2000), and in other parts of North America by Hight et al. (1995), Weibe et al. (2001), Dech & Nosko (2002), and Lindgren (2003).

Since the first release of these exotic agents for biological control of purple loosestrife in 1992, several publications have expressed concern that the adverse impact of purple loosestrife on native vegetation has been overstated and has not been adequately documented (Anderson, 1995; Hager & McCoy, 1998; Treberg & Husband, 1999; Farnsworth & Ellis, 2001; Houlahan & Findlay, 2004). Blossey et al. (2001) provided a summary of the negative impacts caused by purple loosestrife ranging from decline in quality bird habitat and reduction in plant biodiversity to alteration of wetland function.

The purpose of this study was to document infestations of purple loosestrife in western Virginia (and northeastern Tennessee) over an 11-year period. Documenting the location and size of purple loosestrife infestations over an extended period of time will help in determining the threat of purple loosestrife to native riverine plant species. Future workers can use these data to assess the status and long-term impact of purple loosestrife and help determine the effects of this species on wetland and riverine ecosystems.

MATERIALS AND METHODS

Distribution of *L. salicaria* infestations were monitored from 1991 to 2002 along the Clinch, James, and Maury rivers in Virginia. Surveys were made on the Guest River, a tributary of the Clinch River beginning at Coeburn in Wise County and downstream of Dungannon on the Clinch River to Sneedville, Hancock County, Tennessee. Surveys on the James River drainage were from Dunlap Creek near Sweet Chalybeate in Alleghany County through Botetourt and Rockbridge counties to Amherst and Bedford counties at Big Island. The Maury River drainage was surveyed from Cabin Creek in Millboro to Mill Creek, Bath County to the Calfpasture River in Goshen through Rockbridge County to its confluence with the James River at Glasgow.

Surveys were conducted in late July and August when purple loosestrife is in full bloom and the tall magenta inflorescences are highly visible. We drove along roads paralleling the waterways and where access was possible to the waterway. The presence or absence of purple loosestrife was recorded. These sites were usually at bridge crossings or where the road came close enough to the waterway to allow access. The number of purple loosestrife plants was counted at each site. Locations where no purple loosestrife was present but were open and similar to infested sites with respect to plant species and terrain were selected as sites as well.

At large infestations, the number of square meters of purple loosestrife was recorded. The plant species found within 1 to 2 meters of each purple loosestrife infestation were recorded at all sites. Abundance of associated plant species was categorized during the 2000 and 2002 surveys into three classes of percent area covered: uncommon (1-33%), common (34-66%), and abundant (67-100%). Plant species were determined as native or non-native according to Harvill et al. (1992). To document the location of each site the UTM (Universal Transverse Mercator, zone 17, North American Datum 1927) coordinates were recorded using a Magellan GPS315®, global positioning satellite recorder.

A linear regression was done on each site to determine change in loosestrife density with year as the independent variable and plant density as the dependent variable. A negative slope was interpreted as a decrease in density, a positive slope an increase and a slope of zero as no change. Change in density between the cobble and riverbank habitats not influenced by biological control agents or human disturbances was compared using ordinal logistics (SAS, 1985).

RESULTS

Clinch River

Nineteen sites were monitored from 1991 to 2002 (Fig. 1 and Table 1) in the Clinch River drainage. The source of the purple loosestrife infestation in the Clinch River drainage was determined to be 1.5 km upstream of site C1 (Fig. 1). No purple loosestrife was found upstream of this area on Little Toms Creek. This stream flows into the Guest River which flows into the Clinch River 8 km upstream of Dungannon. No purple loosestrife was found in the Clinch River upstream of the confluence of the Guest River. This suggests that the infestation of purple loosestrife along the Clinch River originated in Coeburn. The Coeburn town manager stated that purple loosestrife had been present since the mid-1970s. It was thought to have been planted as an ornamental near the stream. The town had been trying to control purple loosestrife because it aggravates flooding by catching debris that flows downstream during floods. In the past the herbicide Rodeo® (glyphosate) and mowing were used to control purple loosestrife but with little impact. In 1995 the stream was channelized to remove extensive silt build up. The channelizaltion involved removing approximately 0.5 m of the soil in and along the stream. The stream bank was then seeded with a grass seed mixture consisting primarily of *Poa pratensis* L. Purple loosestrife density was reduced but still remained a problem.

The largest infestation was site C1 located between two railroad bridges separated by 0.6 km along Little Toms Creek. Purple loosestrife was found 3 to 4 meters on either side of the stream between the two bridges. *Galerucella calmariensis*, *G. pusilla*, and *H. transversovittatus* were released at this site in 1992 (McAvoy et. al., 1997, 2002). With establishment of the biological control agents, purple loosestrife significantly decreased from approximately 15,000 plants in 1992 to 1,500 plants in 2002 (McAvoy et al., unpublished data). Purple loosestrife density was inversely related to the number of associated plant species based on square meter plots located throughout this infestation. Another factor that may be contributing to its decrease is competition from other plant species such as *Arundinaria gigantea* (Walter) Muhl. (Table 2), a native grass that can grow taller than the shade-intolerant purple loosestrife and forms thick mats preventing seed germination. Non-native and aggressive species such as *Rosa multiflora* Murray and *Lonicera japonica* Thunberg were also present (Table 2) and may have contributed to its decrease. *Galerucella* spp. were observed at site C2 for the first time in 2003 approximately 6 km downstream of the original release site (C1), eleven years after their release (Fig. 1).

The streams and rivers in western Virginia are typically shaded and allow only a narrow expanse of suitable habitat along the riverbank for a shade-intolerant species such as purple loosestrife. Downstream of site C1, much of the riverbank is shaded by woody plants. Purple loosestrife increased at five (31%; C2, C3, C4, C5, and C10) of the 16 sites not impacted by biological control agents or human activities (Tables 1 and 3). Purple loosestrife often grew in disturbed areas at the base of bridge abutments composed of gravel and stream cobble with *Salix nigra* Marshall and *Platanus occidentalis* L. (Table 2). These areas are prone to flooding that causes scouring, providing open areas for germination of purple loosestrife. Purple loosestrife often establishes itself on waste areas, dumps, and construction areas (Stuckey, 1980; Wilcox, 1989). Establishment of purple loosestrife has also occurred on bare soils exposed after lowering of the water level (Harris & Marshall, 1963). Site C4 had the greatest increase from six plants in 1991 to 100 plants in 2002. This infestation was in a rocky area near a bridge abutment associated with *S. nigra* and *P. occidentalis* (Table 2).

The number of purple loosestrife plants decreased at six (C6, C8, C9, C12, C14, and C15) of the nine

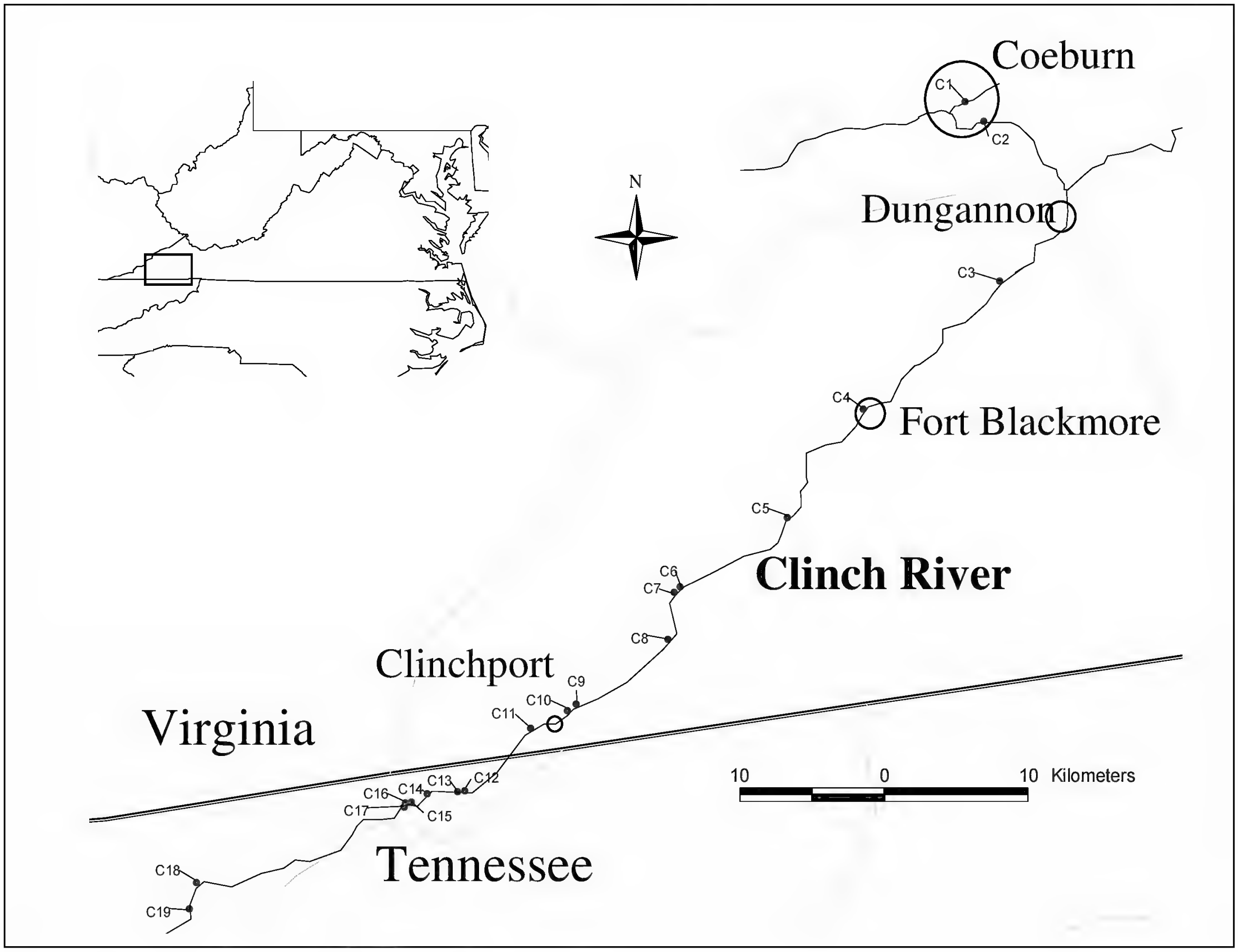

Fig. 1. Purple loosestrife sites in the Clinch River drainage.

riverbank sites unaffected by biological control agents or human activities. These sites were along shaded, undisturbed riverbanks that are not optimal for purple loosestrife growth (Table 1). Of the seven sites that were open cobble bars (C3, C4, C7, C10, C13, C16, and C17), four had decreases in purple loosestrife (C7, C13, C16, and C17). *Justicia americana* (L.) Vahl was the most commonly found species followed by purple loosestrife and *Phalaris arundinacea* L. (Table 2). *Phalaris arundinacea* forms thick monospecific populations similar to *A. gigantea*. Rachich & Reader (1999) reported that removal of *P. arundinacea* was required for purple loosestrife seed germination. No purple loosestrife seeds germinated when they were sown in an existing, undisturbed stand of *P. arundinacea* and thus may be less susceptible to purple loosestrife invasion. Although *P. arundinacea* is considered invasive (Morrison & Molofsky, 1999), it has been reported to support 10 species of insects (Beaulieu et al., 2002) and therefore is a valuable component of the riverine ecosystem as a food source for these insects. *Justicia americana* also produces monospecific populations, but on gravel bars in shallow water below the water level preferred by *P. arundinacea*. It is shorter in height than *P. arundinacea* and may be more susceptible to infestation. However, Carter & Grace (1986) reported that aqueous leachates of decomposing *J. americana* reduced seedling growth of *Polygonum lapathifolium* L, a common annual colonizer of exposed mudflats. This may indicate allelopathy, but the effects of *J. americana* leachate on purple loosestrife is unknown. *Justicia americana* is an important riverine species with respect to biomass production and support of invertebrate species. In the Virginia section of the upper New River it was found to produce 4-5 times more aquatic macrophyte matter than other major aquatic species (Hill, 1981; Hill & Webster, 1982). *Justicia americana* was the only

Table 1. Distribution and abundance of *L. salicaria* along the Clinch River drainage in Virginia and Tennessee.

Site Number	UTM[a] East	North	Estimated distance from source[b] (km)	Habitat	Year	Number of *L. salicaria* plants	Slope	Status
C1[1*]	369225	4089300	0.8	River bank	1992	15,000		
					1998	6,000		
					2000	1,500		
					2002	1,500	-1446	decrease
C2	370240	4087830	6.8	River bank	1992	10		
					1998	15		
					2000	20		
					2002	30	1.79	increase
C3	369592	4076882	29.2	Cobble	1991	20		
					1992	22		
					1993	20		
					1998	10		
					2000	20		
					2002	30	0.30	increase
C4	358820	4069887	44.5	Cobble	1991	6		
					1992	4		
					1993	4		
					1998	7		
					2000	50		
					2002	100	7.13	increase
C5	352423	4063536	57.3	River bank	1991	7		
					1993	4		
					1998	12		
					2000	20		
					2002	20	1.46	increase
C6	344286	4060116	66.1	River bank	1991	5		
					1993	40		
					1998	15		
					2000	20		
					2002	0	-1.14	decrease
C7	343847	4059824	67.4	Cobble	1993	10		
					1998	0		
					2000	6		
					2002	6	-0.44	decrease
C8	342900	4056950	71.3	River bank	1991	1		
					1992	3		
					1994	2		
					1998	0		
					2000	0		
					2002	0	-0.22	decrease
C9	335845	4053511	79.2	River bank	1992	2		
					1994	3		
					1998	0		
					2000	0		
					2002	0	-0.29	decrease

Table 1. (continued).

Site Number	UTM[a] East	North	Estimated distance from source[b] (km)	Habitat	Year	Number of *L. salicaria* plants	Slope	Status
C10	335207	4053130	80.0	Cobble	1994	0		
					1998	0		
					2000	0		
					2002	1	0.10	increase
C11	332490	4052422	83.4	River bank	1994	4		
					1998	4		
					2000	4		
					2002	4	0	no change
C12	327259	4049228	89.5	River bank	1994	3		
					1998	0		
					2000	0		
					2002	0	-0.39	decrease
C13	326747	4049031	92.1	Cobble	1994	25		
					1998	15		
					2000	15		
					2002	12	-1.59	decrease
C14	324650	4049400	92.6	River bank	1994	15		
					1998	2		
					2000	2		
					2002	0	-1.87	decrease
C15	323445	4048816	94.4	River bank	1994	12		
					1998	4		
					2000	0		
					2002	0	-1.60	decrease
C16	323022	4048848	96.0	Cobble	1994	3		
					1998	0		
					2000	2		
					2002	0	-0.30	decrease
C17	322900	4049650	96.5	Cobble	1994	1		
					1998	0		
					2000	0		
					2002	0	-0.13	decrease
C18	307762	4045872	117.6	Cobble	1994	0		
					2000	0		
					2002	0	0	no change
C19	307005	4044370	119.2	Cobble	1994	0		
					2000	0		
					2002	0	0	no change

[a] Universal Transverse Mercator, zone 17, North American Datum 1927.
[b] The source is the purple loosestrife infestation farthest upstream.
[1]*G. pusilla, G. calmariensis,* and *H. transversovittatus* released and established.
*Site impacted by biological control agents or human activities.

Table 2. Relative abundance [a] of plant species associated with *Lythrum salicaria* L. along the Clinch River (2000 and 2002).

Species	# of sites present	Site number[1]															
		C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8	C 9	C 10	C 13	C 15	C 16	C 17	C 18	C 19
Lythrum salicaria L.[+]	11	C	U	U	C	U	U		C	U	U	U			U		
Justicia americana (L.) Vahl	10			U	U	C	U	U			A	C		U		C	C
Phalaris arundinacea L.	7			C	C	U	A	A				C				U	
Salix nigra Marshall	5			U	U	U				U				C			
Arundinaria gigantea (Walter) Muhl.	2	A	C														
Impatiens sp.	2	U	U														
Carex spp.	1			U													
Eupatorium spp.	1					U											
Lonicera japonica Thunberg [+]	1	U															
Platanus occidentalis L.	1					U											
Poa pratensis L.	1	U															
Polygonum spp.	1												U				
Pueraria lobata (Willd.)Ohwi[+]	1												U				
Rosa multiflora Murray [+]	1	U															
Rumex spp.	1													U			
Verbesina sp.	1	U															

[a]U = uncommon, C = common, and A = abundant.
[+]Exotic species.
[1]No data available for sites C11, C12, and C14.

macrophyte species associated with *Notiphila carinata* Loew (Diptera: Ephydridae) (Deonier et al., 1978). *Eupera cubensis* (Prime) (Bivalvia: Sphaeriidae) was commonly found associated with *J. americana* in Kansas (Mackie & Huggins, 1976). *Justicia americana* and *P. arundinacea* may be threatened if purple loosestrife becomes the dominant species in their habitats. Sites C8 - C10 (Table 4) are less than 0.3 km from the rare plant species *Cimicifuga rubifolia* Kearney which grows in habitats similar to purple loosestrife. This area should be monitored for infestation of purple loosestrife into this rare plant population.

Site C17, which is 96 km downstream of the initial infestation, was the last site where purple loosestrife was observed on the Clinch River. Although no purple loosestrife was found at sites C18 and C19, located 118 and 119 km downstream, respectively, of the source, these two sites are open gravel bars dominated by *J. americana*. Sites similar to these are infested with purple loosestrife and these two sites may become infested in the future.

Excluding purple loosestrife, only three other non-native species were observed in this survey. Two of these species, *L. japonica* and *R. multiflora,* were observed only at site C1, the most disturbed site surveyed (Table 2). The third exotic species, *Pueria lobata* (Willd.) Ohwi was found at site C15.

Sites C2 – C5 were closer to the source and presumably older than the sites downstream. Downstream of C6 the density was much lower, with a maximum of 25 plants at C13, which is 92.1 km from the source. Loosestrife density either did not change or decreased in density at sites downstream of C6 with the exception of C10. If the sites were infested in order of proximity to the initial source, the age of each infestation should decrease with increased distance from the source. These sites were possibly between 10 and 25 years old at the time of this study. Stuckey (1980) indicated that purple loosestrife will begin to aggressively spread 20-40 years after the initial infestation.

Table 3. Status of purple loosestrife infestations in riverbank and cobble habitats not influenced by biological control agents or human activity.

River[1]	Number of sites			
	Decrease	No change	Increase	Total
Clinch	10	1	5	16
Maury	3	3	4	10
James	6	3	8	17
Total	19	7	17	43
Habitat[2]				
River bank	12	8	4	24
Cobble	5	2	10	17
Total	17	10	14	41

[1] Includes observations from 1991 to 2002.
[2] Includes observations from 1998 to 2002.

Table 4. Purple loosestrife sites within 0.3 km of rare plant populations (J. F. Townsend, pers. comm.).

Family	Species	Common name	Rank[1] Global	Rank[1] Virginia	Sites
Capparaceae	*Polanisia dodecandra* (L.) DC.	Common clammy-weed	G5T?	S2	J11, J19
Melastomataceae	*Iliamna remota* Greene	Kankakee globe-mallow	G1Q	S1	J8, J19, J21
Poaceae	*Elymus canadensis* L.	Nodding wild rye	G5	S2?	J8
Poaceae	*Spartina pectinata* Link	Freshwater cordgrass	G5	S2	M9
Ranunculaceae	*Cimicifuga rubifolia* Kearney	Appalachian bugbane	G3	S2	C8, C9, C10
Rubiaceae	*Spermacoce glabra* Michaux	Smooth buttonweed	G4G5	S1	J19
Vitaceae	*Vitis rupestris* Scheele	Sand grape	G3	S1?	M9

[1] Global and state rankings are categorized as reported by Townsend (2005).

Maury River

Two possible sources of purple loosestrife were found in the James River drainage (Fig. 2). One source was located in the Maury River drainage in the community of Millboro at the head of Cabin Creek where a large infestation of purple loosestrife was found with over 1,000 plants (sites M1 and M2, Table 5). Local community members indicated that a beekeeper may have planted purple loosestrife as a nectar source for honeybees (Pellett, 1966). Pellett (1977), an avid beekeeper, enthusiastically described how purple loosestrife spread down the Raccoon River in Iowa and provided instructions on how to propagate it. Purple loosestrife is present in many drainage ditches along the roads and railroad track in Millboro. In 1996, *G. pusilla* and *G. calmariensis* were released at sites M1 and M2, respectively. Both species were observed at these two sites for several years after their release. In 2000, site M1 was channelized and this may account for the reduction in purple loosestrife. However, purple loosestrife had increased in abundance in the area channelized during visits in 2002. At site M3, it grew among the rocks of Mill Creek and declined from approximately 50 plants in 1994 to five plants in 2002. Cabin Creek enters Mill Creek approximately 4 km upstream of this site (Fig. 2).

The largest site in the Maury River drainage was M5, a 0.5 ha infestation 13.4 km downstream of the source (M1). This site is bordered by a raised railroad track and a highway (Rt. 42). Several springs flow into this site creating a marginal wetland. This site is approximately 0.5 km north of Mill Creek and 3-5 meters above the normal water level of the stream. In November 1985, a major flood occurred in this area and water from Mill Creek inundated this site. Within one or two years, purple loosestrife was observed growing here by the farmer who manages an adjacent field. Thus, this site was probably nine years old at the beginning of this study in 1994.

The biological control agents *G. calmariensis*, *G. pusilla*, and *H. transversovittatus* were released at site M5 beginning in 1994 (Table 5). The latter species is now well established at this site (McAvoy et al., 2002). Both *Galerucella* spp. were observed at this site every year since their release but in very low numbers and no impact has been observed at this site by the biological control agents. Although this site had the greatest number of associated plant species (n = 7) (Table 6), many areas of this site were completely dominated by purple loosestrife and in these areas it had very few associated species. Unfortunately, new owners of this site began mowing this area in 2002.

Another large infestation was found along the Calfpasture River (M4) in a large, rocky cobblestone area along the river. In 2000, a flood scoured much of the loosestrife away, but by 2002 it had reestablished its dominance. Site M6 is similar to site M5, being several feet above the normal river level and not in direct contact with any large water source. Purple loosestrife is found here in open, dry abandoned fields, and along drainage ditches. This area was likely flooded also in 1985, perhaps introducing purple loosestrife seeds. No change in purple loosestrife density has occurred here. Another large infestation is at the Maury Monument wayside in the Goshen Pass (M8), 23.2 km downstream of the source. Purple loosestrife density has increased substantially at this site from 250 plants in 1994 to approximately 1,500 plants in 2002. This is an open rocky area along the river and is often flooded, which may contribute to the dominance of purple loosestrife. Site M9, also in the Goshen Pass, has remained stable with approximately 12 plants. However, this site is less than 0.2 km from *Vitis rupestris* Scheele and *Spartina pectinata* Link (J. F. Townsend, pers. comm.) populations (Table 4). These sites should be monitored for any impact by purple loosestrife on these rare species. Three other sites (M10 - M12) were identified between the Goshen Pass and the Maury River's confluence of the James River. Site M10 increased from

Table 5. Distribution and abundance of *Lythrum salicaria* along the Maury River, Virginia.

Site Number	UTM[a] East	UTM[a] North	Estimated distance from source[b] (km)	Habitat	Year	Number or area of *L. salicaria* plants	Slope	Status
M1*	622746	4203738	0	River bank	1994	>2,000		
					1996[2]	>2,000		
					1998[5]	>2,000		
					2002[5]	1,000	-128.6	decrease
M2	623126	4203878	0.8	River bank	1998	500 m^2		
					1996[3]	500 m^2		
					2000[6]	500 m^2		
					2002[6]	500 m^2	0	no change
M3	628583	4206915	7.6	Cobble	1994	50		
					1998	1		
					2000	0		
					2002	5	-5.94	decrease
M4	632250	4205000	13.2	Cobble	1994	2,000 m^2		
					1998	2,000 m^2		
					2000	500 m^2		
					2002	1,200 m^2	-144.3	decrease
M5	632550	4205550	13.4	wetland	1994[1, 2, 3]	0.5 ha		
					1998[4, 5, 6]	0.5 ha		
					2000[4, 5, 6]	0.5 ha		
					2002[4, 5, 6]	0.5 ha	0	no change
M6	631758	4204411	14.0	River bank	1994	2,000 m^2		
					1998	2,000 m^2		
					2000	2,000 m^2		
					2002	2,000 m^2	0	no change
M7	631350	4203260	15.3	River bank	1994	3		
					1998	4		
					2000	0		
					2002	0	-0.44	decrease
M8	635726	4199136	23.2	Cobble	1994	250		
					1998	1,000		
					2000	1,000		
					2002	1,500	146.4	increase
M9	636157	4199001	23.5	Cobble	1994	12		
					1998	10		
					2000	12		
					2002	12	0.03	increase
M10	641615	4179706	65.2	Cobble	1998	6		
					2000	8		
					2002	40	8.50	increase
M11	637303	4168837	85.7	River bank	1993	1		
					1998	2		
					2000	4		
					2002	12	1.03	increase

[a] Universal Transverse Mercator, zone 17, North American Datum 1927.
[b] The source is the purple loosestrife infestation farthest upstream.
[1] *H. transversovittatus* released. [2] *G. pusilla* released. [3] *G. calmariensis* released.
[4] *H. transversovittatus* established. [5] *G. pusilla* established. [6] *G. calmariensis* established.
* Site impacted by biological control agents or human activities.

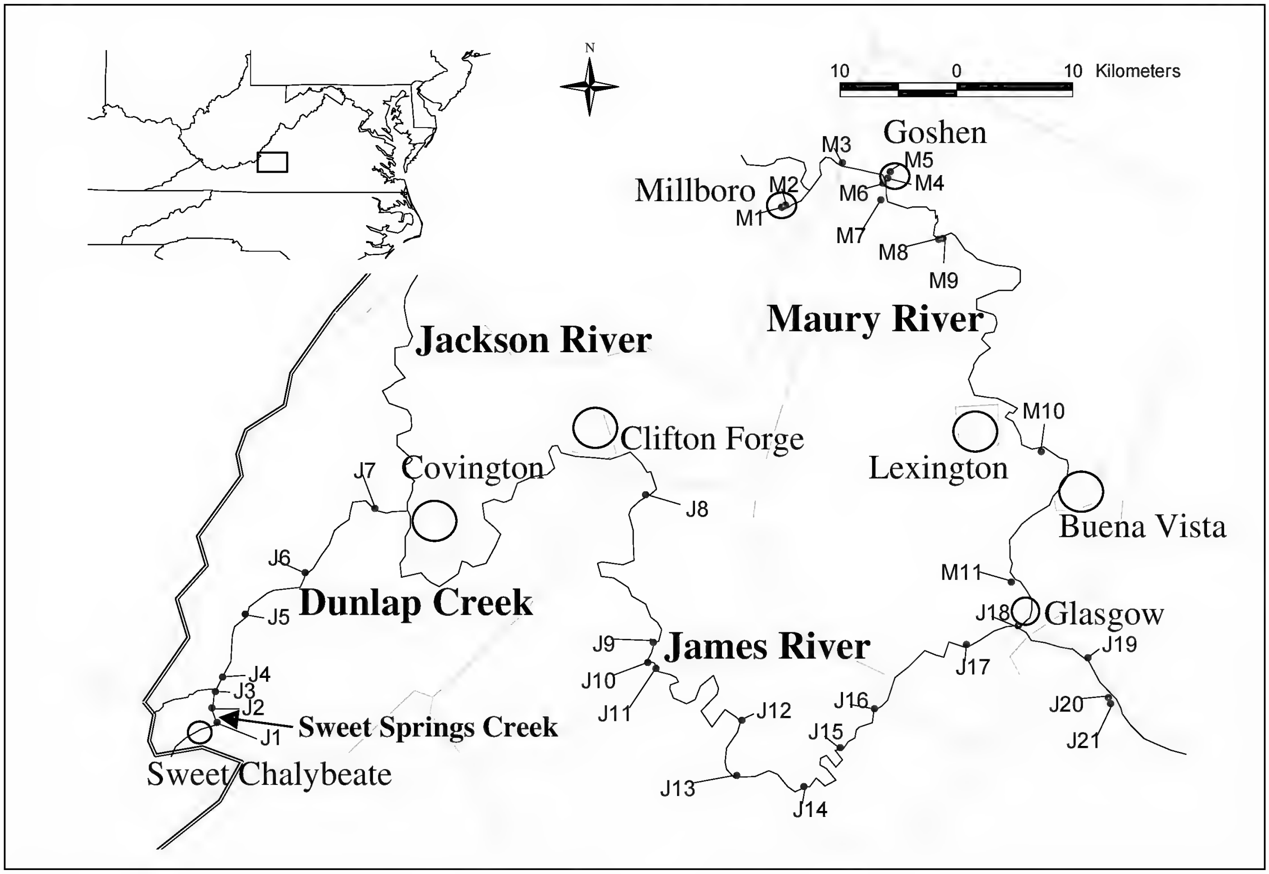

Fig. 2. Purple loosestrife sites in the Maury and James river drainages.

approximately six plants in 1998 to 40 plants in 2002. This infestation is in an open gravel bar and is the only site found in the Maury River with *J. americana.* Site J18 (Table 7) is at the confluence of the Maury and James rivers, 90.5 km downstream of the Maury River infestation source. Purple loosestrife density did not change at three sites, increased in density in four sites, and decreased in three sites (Tables 3 and 5). The decrease at site M1 was manmade.

As in the Clinch River drainage, the sites closest to the original infestation had the highest density of purple loosestrife. However, site M8, 23.2 km downstream of the original infestation had 2,000 m^2 of purple loosestrife. The area of infestation at sites M1, M2, and M4-M6 (Table 5) was greater than at other sites because of the large, open, and level terrain. Susceptibility of these sites to loosestrife infestation probably accounted for the size of infestation rather than age of infestation. Three (M8-M10, Table 5) of the four sites that increased in the Maury River drainage were in cobble areas indicating that these sites are more susceptible to invasion and prolonged infestations than the riverbank habitats. Sites downstream of M8 had a narrower area of potential infestation and subsequently had lower numbers of plants.

Five other exotic species were observed in the Maury River study area (Table 6). *Arthraxon hispidus* (Thund.) was the most common exotic species and was found at sites M4 - M6, M8, M10, and M11. Other exotics species observed were *Dipsacus fullonum* L. (M5 and M6), *Humulus japonicus* Siebold & Zucc. (M11), *Lysimachia nummularia* L. (M2), and *Poa trivialis* L. (M1). No rare plant species that occupy a similar habitat as purple loosestrife has been recorded along the Maury River (J. F. Townsend, pers. comm.).

James River

The James River infestation likely began at health spring resorts located along Sweet Springs Creek (Fig. 2). Site J1 was the farthest site upstream in the Jackson River drainage, a tributary of the James River. This site is 1.6 and 3.0 km downstream from two former health springs, Sweet Springs and Sweet Chalybeate Springs,

Table 6. Relative abundance[a] of plant species associated with *Lythrum salicaria* along the Maury River (2000 and 2002).

Species	# of sites present	Site number[1]										
		M1	M2	M3	M4	M5	M6	M8	M9	M10	M11	M12
Lythrum salicaria L.[+]	11	C	C	U	A	A	C	C	U	U	U	U
Arthraxon hispidus (Thunb.) Makino [+]	6				C	C	U	C		U	U	
Carex spp.	6		U		U	C		U		U		U
Phalaris arundinacea L.	3				C					U	A	
Cyperus spp.	2							U			U	
Dipsacus fullonum L.[+]	2					U	U					
Impatiens sp.	2	U										U
Juncus effusus L.	2		U			U						
Platanus occidentalis L.	2							U			U	
Salix nigra Marshall	2						U	U				
Solidago spp.	2					U	U					
Typha latifolia L.	2				U		U					
Acer negundo L.	1										U	
Apocynum sp.	1					U						
Bidens spp.	1											U
Cardamine rotundifolia Michaux	1	U										
Humulus japonicus Siebold & Zucc.[+]	1										U	
Justicia americana (L.) Vahl	1									U		
Lespedeza sp.	1							U				
Lysimachia nummularia L.[+]	1		U									
Myosotis laxa Lehmann	1					U						
Poa trivialis[+] L.	1	U										
Ranunculus spp.	1		U									
Vernonia noveboracensis (L.) Michaux	1											U

[a] U = uncommon, C = common, and A = abundant.
[+] Exotic species.
[1] No data available for site M7.

respectively (Table 7). Sweet Springs was a resort begun in 1792, and Sweet Chalybeate Springs located in the community of Sweet Chalybeate was begun in 1850 (Morten, 1916). One or both of these resorts may have been the source of the present infestation of purple loosestrife since it was often planted as a medical or ornamental at health springs during the 19th century (Stuckey, 1980). Purple loosestrife was reported from two West Virginia resorts in the 19th century: Salt Sulfur Springs in Monroe County (Stuckey, 1980) and Mercer Springs in Mercer County (McNeil, 1938). Both of these resorts are in the New River drainage. Based on these records, purple loosestrife may have been planted at Sweet Springs and Sweet Chalybeate Springs resorts. However, no purple loosestrife was found in the immediate area of these resorts during this study. The Sweet Springs resort has been unoccupied for many years, but the property is mowed and few weedy areas remain. Sweet Chalybeate Springs and former cottages are now privately owned. This area is also mowed and livestock graze the surrounding fields.

Site J1 is immediately below a culvert under Rt. 311 that drains a small tributary of Sweet Springs Creek (Table 7). Releases of *G. pusilla* and *H. transversovittatus* were made at this site in 1993. *Galerucella pusilla* was found for several years after its release, but in 1999 the stream was dredged and mowed, and very little purple loosestrife remains.

Site J2 at the two Beaverdam Falls is a very large infestation. Purple loosestrife was common 100 m upstream of the upper falls, and 0.5 km downstream of the lower falls. Both falls were heavily infested. The upstream portions of the stream flow through unfenced pastures allowing livestock access to the stream. Grazing by livestock may have reduced or eliminated purple loosestrife from these areas. The stream between the two falls is fenced to restrict livestock and may account for the high density of purple loosestrife. *Galerucella calmariensis* and *H. transversovittatus* were released at this site in 1994. *Galerucella calmariensis* became well established and in 1998 nearly 100% defoliation of purple loosestrife occurred. Purple loosestrife density since then has been greatly reduced and *P. arundinacea* is now the most abundant species at this site (Table 8).

Downstream of site J2 the habitat is similar to that found along the Clinch and Maury rivers, with shaded riverbanks and abundant woody vegetation. Most sites had fewer than 50 plants, except for three sites (J8, J10, and J20) which had over 100 plants each (Table 7).

Table 7. Distribution and abundance of *L. salicaria* along the James River, Virginia.

Site number	UTM[a] East	UTM[a] North	Estimated distance from source[b] (km)	Habitat	Year	Number or area of *L. salicaria* plants	Slope	Status
J1*	567350	4167900	1.6	River bank	1992[1,2]	75		
					1993	75		
					1998	75		
					2000	75		
					2002	0	-4.93	decrease
J2*	567150	4169180	3.1	River bank	1992	2,000		
					1994[1,3]	2,000		
					1998[6]	2,000		
					2000[6]	1,000		
					2002[6]	500	-145.35	decrease
J3	567661	4170269	5.2	River bank	1992	4		
					1998	10		
					2000	3		
					2002	4	-0.04	decrease
J4	568446	4171402	7.3	River bank	1992	0		
					1998	1		
					2000	12		
					2002	1	0.50	increase
J5	571284	4176467	14.2	River bank	1992	0		
					1998	5		
					2000	4		
					2002	0	0.14	increase
J6	576936	4179181	23.9	River bank	1992	0		
					1998	10		
					2000	10		
					2002	8	0.93	increase
J7	583870	4183890	36.9	River bank	1992	0		
					1998	0		
					2000	0		
					2002	0	0	no change
J8	607387	4181286	81.1	Cobble	1992[1, 2, 3]	100		
					1998	200		
					2000	1,000		
					2002	1,000	96.43	increase
J9	605827	4168544	100.7	Cobble	1991	2		
					1992	0		
					1998	4		
					2000	15		
					2002	3	0.65	increase
J10*	605070	4167118	103.2	River bank	1991	4		
					1992	3		
					1998	4		
					2000	3		
					2002	200	11.13	increase
J11	605657	4166289	103.9	River bank	1991	10		
					1992	2		
					1998	4		
					2000	0		
					2002	4	-0.40	decrease

Table 7. (continued).

Site number	UTM[a] East	UTM[a] North	Estimated distance from source[b] (km)	Habitat	Year	Number or area of *L. salicaria* plants	Slope	Status
J12	612291	4160764	124.8	Cobble	1991	5		
					1998	150		
					2000	30		
					2002	20	2.27	increase
J13	611126	4156140	162.9	Cobble	1991	3		
					1998	20		
					2000	10		
					2002	10	0.72	increase
J14	616692	4154274	170.3	River bank	1993	3		
					1998	3		
					2000	4		
					2002	0	-0.21	decrease
J15	620339	4157051	179.8	River bank	1993	10		
					1998	5		
					2000	0		
					2002	0	-1.20	decrease
J16	623818	4159951	186.1	River bank	1993	2		
					1998	2		
					2000	2		
					2002	2	0	no change
J17	632541	4164121	197.1	River bank	1993	8		
					1998	0		
					2000	0		
					2002	0	-0.94	decrease
J18	637200	4165019	202.6	River bank	1993	8		
					1998	20		
					2000	20		
					2002	6	0.23	increase
J19	642800	4161600	216.9	Cobble	1993	50		
					1998	50		
					2000	50		
					2002	50	0	no change
J20	644000	4157900	221.5	wetland	1998	1500 m^2		
					1999[1, 2, 3]	1500 m^2		
					2000[4, 5, 6]	1500 m^2		
					2002[4, 5, 6]	1500 m^2	0	no change
J21	644100	4157400	221.9	River bank	1993	12		
					1998	4		
					2002	2	-1.13	decrease

[a] Universal Transverse Mercator, zone 17, North American Datum 1927.
[b] The source is the purple loosestrife infestation farthest upstream.
[1] *H. transversovittatus* released. [2] *G. pusilla* released. [3] *G. calmariensis* released.
[4] *H. transversovittatus* established. [5] *G. pusilla* established. [6] *G. calmariensis* established.
*Site impacted by biological control agents or human activities.

Table 8. Relative abundance [a] of plant species associated with *Lythrum salicaria* along the James River (2000 and 2002).

Species	# of sites present	Site number[1]																	
		J1	J2	J3	J4	J5	J6	J8	J9	J10	J11	J12	J13	J15	J16	J17	J18	J19	J20
Lythrum salicaria L.[+]	16	C	C	U	U	U	U	U	U	C	U	U	C		U		U	C	A
Impatiens spp.	7	C	C		U		U			U							U		U
Platanus occidentalis L.	7				U	C	U	C						C	U	U			
Eupatorium spp.	6		C	U	U			U	C			U							
Justicia americana (L.) Vahl	5								U		A	C	A	U					
Salix nigra Marshall	5				U		U	U							U	U			
Phalaris arundinacea L.	4		A	C	U		U												
Vernonia noveboracensis (L.) Michaux	4						U		U			U					U		
Verbesina sp.	4	C		U		U				U									
Uniola latifolia Michx.	3										U	U			U				
Carex spp.	2									U							U		
Dipsacus fullonum L.[+]	2	C	U																
Mentha spicata L.[+]	2		U	U															
Acer negundo L.	1															C			
Bidens spp.	1																U		
Cephalanthus occidentalis L.	1														U				
Equisetum spp.	1					U													
Lysimachia nummularia L.[+]	1																		U
Microstegium vimineum (Trinius) [+]	1																		U
Myosotis laxa Lehmann	1																		U
Oenothera biennis L.	1									U									
Polygonum spp.	1																		U
Polymnia uvedalia (L.) L.	1									U									
Sorghum halepense (L.) Persoon[+]	1								U										
Typha latifolia L.	1																		U

[a] U = uncommon, C = common, and A = abundant.
[+] Exotic species
[1] No data available for sites J7, J14, and J21.

Purple loosestrife increased at eight sites not affected by biological control agents or human influences. Half of these were cobble sites. All three biological control agents were released at site J8 in 1992, but they have not been observed since the release. Site J10 was a small infestation with approximately four plants in 1993 growing in the depression of a canal lock of the former James River and Kanawha Canal (Langhorne, 2000) and remained stable until 2002. In 2000, this site was sprayed with herbicide. In 2002, the number of purple loosestrife plants increased to approximately 200. The increase in purple loosestrife may be a result of the death of competing plants allowing the purple loosestrife to germinate and quickly dominate the site. Gabor et al. (1996) reported that after removal of purple loosestrife with herbicide, native vegetation predominated for a time but subsequently was replaced by purple loosestrife. Site J11 is less than 0.2 km from a population of the rare plant, *Polanisia dodecandra* (L.) DC (Table 4). Eleven more sites were observed downstream of site J10 with 50 or fewer plants. A decrease in purple loosestrife occurred at five of these sites (J11, J14, J15, J17, and J21). No purple loosestrife was observed at three sites (J14, J15, and J17) that were infested before 2002 (Table 7). Purple loosestrife at site J14 was mowed in 2002. Reduction at sites J15 and J17 may be due to the increase in *P. occidentalis* and *S. nigra* (Table 8). Site J19 was within 0.2 km of rare plant populations of *Polanisia dodecandra* (L.) DC., *Iliamna remota* Greene, and *Spermacoce glabra* Michaux (Table 4).

Site J18 is at the confluence of the James and Maury rivers (Fig. 2). Below this point there are two possible original sources of purple loosestrife, one from the Maury River (M1) and the other from the upper James River (J1), 90.5 km and 202.6 km upstream, respectively, of the confluence of these rivers. The possible source is J1. Since it is possible that purple loosestrife was planted at the resorts in the 19th century, it could have a much longer presence in this section of

the river and would have reached this point in the river sooner. Currently, seeds from both sources now occur below the confluence because purple loosestrife is found along the Maury River just upstream (M11) of site J18.

The largest infestation on the James River drainage was site J20, 3 km north of Big Island, Virginia and 221.5 km downstream of J1. This infestation grows in a depression formed by the James River and Kanawha Canal (Langhorne, 2000). Several springs flow into this area creating a wetland. The canal in this section of the James River was built during the 1850s. Approximately 1,500 m^2 of purple loosestrife was found in an area approximately 500 m long and 20 m wide in the old canal. In 1999, *G. calmariensis*, *G. pusilla*, and *H. transversovittatus* were released at this site. All three species have been observed since their release and are now established at this site (McAvoy et al., 2002), but no reduction in purple loosestrife has been observed. The exotic species *Microstegium vimineum* (Trinius) and *Lysimachia nummularia* L. were observed at this site (Table. 8). The former was the dominant species in some areas, covering approximately 50 m^2. It is a very aggressive, shade-tolerant species that has restricted native species (Barden, 1987), as well as affected soil properties (Kourtev et al., 1998, 2002). A population of the rare plant *Iliamna remota* Greene (Table 4) has been recorded growing within this site but has not been seen during our surveys. This area should also be monitored for this rare species for any impact by purple loosestrife. Access to the river downstream of site J21 below Big Island was limited and no further sites were investigated.

No change in purple loosestrife density occurred at three (18%) of the 17 sites not affected by biological control agents or human influences. Purple loosestrife decreased in density at six (35%) of the 17 sites and increased in eight (47%) sites (Tables 3 and 7).

DISCUSSION

Based on observations from the 43 sites not impacted by biological control agents or human activities over a nine to 11-year period on the Clinch, James, and Maury rivers, purple loosestrife abundance did not change in 16% of the sites (n =7), decreased in 44% (n = 19) and increased in 40% (n = 17) of the sites (Table 3). No differences were found in the change in purple loosestrife density between the three river systems studied (P = 0.51). Therefore, the sites in the three rivers responded equally and were combined in the analysis to determine if differences occurred between riverbank and cobble habitats. This analysis was conducted using site densities taken in 1998, 2000, and 2002. Site densities recorded before 1998 were sporadic and not used in this analysis. Of the 14 sites where purple loosestrife increased, ten were open cobble bars disturbed by flooding, while only four were riverbank sites (Table 3). A difference (P = 0.02) was found between the two habitats, with the riverbank habitats decreasing (n = 12) and the cobble habitats increasing in density (n = 10) from 1998 to 2002 (Table 7).

The sites that remained open and disturbed by flooding or human activities showed population increases. These types of sites need to be monitored in the future to detect new infestations or expansion of current infestations. Based on the results of this study, purple loosestrife does not appear to be as invasive in undisturbed river banks as in cobble bars. However, *J. americana* stands were susceptible to invasion by purple loosestrife and warrant continued monitoring. Also, populations of seven rare plant species that prefer habitats similar to purple loosestrife occur along the James and Clinch Rivers. These populations may be threatened by purple loosestrife and need to be monitored. Recruitment of purple loosestrife at sites with a long history of infestation will continue to be a source of new plants, especially following disturbance. Welling & Becker (1990) reported over 400,000 seeds per m^2 in a wetland that had been infested for 5 to 10 years. This infestation was not a monospecific stand and covered only 14% of the study area. With the establishment of biological control agents at more sites, purple loosestrife should decline in the future as was evident at several sites. New and small infestations should be given high priority for control to limit the seed bank.

The presumed age of these infestations varied considerably and may have influenced the size of the infestations. Generally, larger infestations were closer to the initial infestation and presumably older than those downstream. However, the most distant site (J20) from the initial infestation was one of the largest infestations. This infestation is more likely affected by habitat suitability rather than the age of the infestation. Wilcox (1989) reported a distinct east-west gradient in purple loosestrife density along an interstate in New York, but it was influenced by a large infestation of purple loosestrife at the Montezuma National Wildlife Refuge. This concurs with our findings that the quality of habitat can influence the size of the infestation.

Treberg & Husband (1999) conducted a one-year study on sites similar to ours, analyzing the impact of purple loosestrife on species richness along the Bar River in Canada. They reported that purple loosestrife

had no impact on species richness nor was there a reduction of plant species as purple loosestrife density increased. However, Mal et al. (1997) reported that *Typha angustifolia* L., dominant in the first four years of a wetland replacement study, was displaced by purple loosestrife after five years in a wetland habitat. A one-year study of five wet meadows in Connecticut (Farnsworth & Ellis, 2001) indicated that the total biomass of non-purple loosestrife species was negatively correlated with purple loosestrife biomass while no differences were found using density and diversity metrics. Thus, conflicting conclusions can be deduced depending on the metrics used in the study. Riverine and wetland habitats also offer different plant species associations, and ecosystem dynamics need to be considered in long-term forecasting. While invasion of purple loosestrife may be more destructive to wetland habitats (Blossey et al., 2001), it may not be as threatening to the riverbank habitats. However, seeds released from riverbank infestations could be a source of infestations in wetlands downstream and riverine sites should be managed and new infestations controlled (Mal et al., 1997).

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LITERATURE CITED

Anderson, M. G. 1995. Interactions between *Lythrum salicaria* and native organisms: a critical review. Environmental Management 19: 225-231.

Barden, L. S. 1987. Invasion of *Microstegium vimineum* (Poaceae), an exotic, annual, shade-tolerant, C4 grass, into North Carolina floodplain. American Midland Naturalist 118: 40-45.

Beaulieu F., & T. A. Wheeler. 2002. Insects (Diptera, Coleoptera, Lepidoptera) reared from wetland monocots (Cyperaceae, Poaceae, Typhaceae) in southern Quebec. Proceedings of the Entomological Society of Washington 104: 300-308.

Blossey, B., & R. Notzold. 1995. Evolution of increased competitive ability in invasive nonindigenous plants: a hypothesis. Journal of Ecology 83: 387-389.

Blossey, B., D. Schroeder, S. D. Hight, & R. A. Malecki. 1994a. Host specificity and environmental impact of the weevil *Hylobius transversovittatus*, a biological control agent of purple loosestrife (*Lythrum salicaria*). Weed Science 42: 128-133.

Blossey, B., D. Schroeder, S. D. Hight, & R. A. Malecki, 1994b. Host specificity and environmental impact of two leaf beetles (*Galerucella calmariensis* and *Galerucella pusilla*) for biological control of purple loosestrife (*Lythrum salicaria*). Weed Science 42: 134-140.

Blossey, B., L. C. Skinner, & J. Taylor. 2001. Impact and management of purple loosestrife (*Lythrum salicaria*) in North America. Biodiversity and Conservation 10: 1787-1807.

Capel, S. 1993. Purple plague. Virginia Wildlife 54(7): 13-15.

Carter, M. F, & J. B. Grace. 1986. Relative effects of *Justicia americana* litter on germination, seedlings and established plants of *Polygonum lapathifolium*. Aquatic Botany 23: 341-349.

Dech, J. P. & P. Nosko. 2002. Population establishment, dispersal, and impact of *Galerucella pusilla* and *G. calmariensis*, introduced to control purple loosestrife in central Ontario. Biological Control 23: 228-236.

Deonier, D. L., W. N. Mathis, & J. T. Regensburg. 1978. Natural history and life-cycle stages of *Notiphila carinata* (Diptera: Ephydridae). Proceedings of the Biological Society of Washington 91: 798-814.

Farnsworth, E. J., & D. Ellis. 2001. Is purple loosestrife (*Lythrum salicaria*) an invasive threat to freshwater wetlands? Conflicting evidence from several ecological metrics. Wetlands 21: 199-209.

Gabor, T. S., T. Haagsma, & H. R. Murkin. 1996. Wetland plant responses to varying degrees of purple loosestrife removal in southeastern Ontario, Canada. Wetlands 16: 95-98.

Galatowitsch, S. M., N. O. Anderson, & P. D. Ascher. 1999. Invasiveness in wetland plants in temperate North America. Wetlands 19: 733-755.

Hager, H. A., & K. D. McCoy. 1998. The implications of accepting untested hypotheses: a review of the effects of purple loosestrife (*Lythrum salicaria*) in North America. Biodiversity Conservation 7: 1069-1079.

Harris, S. W., & W. H. Marshall. 1963. Ecology of water level manipulation on a northern marsh. Ecology 44: 331-343.

Harvill, A. M., T. R. Bradley, C. E. Stevens, T. F. Wieboldt, D. M. E. Ware, D. W. Ogle, G. W. Ramsey, & G. P. Fleming. 1992. Atlas of the Virginia Flora. Virginia Botanical Associates, Burkeville, VA. 144 pp.

Hight, S. D., B. Blossey, J. Laing, & R. Declerck-Floate. 1995. Establishment of insect biological control agents from Europe against *Lythrum salicaria* in North America. Environmental Entomology 24: 967-977.

Hill, B. H. 1981. Distribution and production of *Justicia americana* in the New River, Virginia. Castanea 46: 162-169.

Hill, B. H., & J. R. Webster. 1982. Aquatic macrophyte breakdown in an Appalachian river. Hydrobiologia 89: 53-59.

Houlahan J. E., & C. S. Findlay. 2004. Effect of invasive plant species on temperate wetland plant diversity. Conservation Biology 18: 1132-1138.

Hultén E. 1971. The Circumpolar Plants. II Dicotyledons. Svenska Vetenskaps Akademiens Handlingar. Almqvist & Wiksell, Stockholm. 13. 463 pp.

Kok, L. T., T. J. McAvoy, R. A. Malecki, S. D. Hight, J. J. Drea, & J. R. Coulson. 1992a. Host specificity tests of *Hylobius transversovittatus* Goeze (Coleoptera: Curculionidae), a potential biological control agent of purple loosestrife, *Lythrum salicaria* L. (Lythraceae). Biological Control 2: 1-8.

Kok, L. T., T. J. McAvoy, R. A. Malecki, S. D. Hight, J. J. Drea, & J. R. Coulson, 1992b. Host specificity tests of *Galerucella calmariensis* (L.) and *G. pusilla* (Duft.) (Coleoptera: Chrysomelidae), potential biological control agents of purple loosestrife, *Lythrum salicaria* L. (Lythraceae). Biological Control 2: 282-290.

Kok, L. T., T. J. McAvoy, & W. T. Mays. 2000. Successful establishment of exotic agents for classical biological control of invasive weeds in Virginia. Pp. 59-65 *In* N. R. Spencer (ed.), Proceedings of the X International Symposium on Biological Control of Weeds, July 4-10, 1999. Bozeman, MT. Advanced Litho Printing, Great Falls, MT.

Kourtev, P. S., J. G. Ehrenfeld, & M. Haggblom. 2002. Exotic plant species alter the microbial community structure and function in the soil. Ecology 83: 3152-3166.

Kourtev P. S., J. G. Ehrenfeld, & W. Z. Huang. 1998. Effects of exotic plant species on soil properties in hardwood forests of New Jersey. Water, Air, and Soil Pollution 105: 493-501.

Langhorne, G. 2000. Cabell's Canal: The Story of the James River and Kanawha. Commodore Press, Richmond, VA. 306 pp.

Lindgren, C. J. 2003. Using 1-min scans and stem height data in a post-release monitoring strategy for *Galerucella calmariensis* (L.) (Coleoptera: Chrysomelidae) on purple loosestrife, *Lythrum salicaria* L. (Lythraceae), in Manitoba. Biological Control 27: 201-209.

Mackie, G. L., & D. G. Huggins. 1976. Biological notes on *Eupera cubensis* (Bivalvia: Sphaeriidae) from Kansas. Journal of the Fisheries Research Board of Canada 33: 1652-1656.

Mal, T. K., J. Lovett-Doust, & L. Lovett-Doust. 1997. Time-dependent competitive displacement of *Typha angustifolia* by *Lythrum salicaria*. Oikos 79: 26-33.

Malecki, R. A., B. Blossey, S. D. Hight, D. Schroder, L. T. Kok, & J. Coulson. 1993. Biological control of purple loosestrife. BioScience 43: 680-686.

McAvoy, T. J., L. T. Kok, & W. T. Mays. 1997. Phenology of an established population of *Galerucella calmariensis* (L.) and *G. pusilla* (Duft.) (Coleoptera: Chrysomelidae) on purple loosestrife, *Lythrum salicaria* L. (Lythraceae), in southwest Virginia. Biological Control 9: 106-111.

McAvoy, T. J., L. T. Kok, & W. T. Mays. 2002. Establishment of *Hylobius transversovittatus* Goeze (Coleoptera: Curculionidae), a biological control agent of purple loosestrife, in Virginia. Biological Control

24: 245-250.

McNeill, E. M. 1938. Plant records from Mercer County, West Virginia and adjoining counties. Castanea 3: 36-39.

Morrison, S. L., & J. Molofsky. 1999. Environmental and genetic effects on the early survival and growth of the invasive grass *Phalaris arundinacea*. Canadian Journal of Botany 77: 1447-1453.

Morten, O. F. 1916. A History of Monroe County. McClure Company, Staunton VA., Reprinted: Regional Publishing Company, Baltimore, 1974. 509 pp.

Nagel, J. M., & K. L. Griffin. 2001. Construction cost and invasive potential: comparing *Lythrum salicaria* (Lythraceae) with co-occurring native species along pond banks. American Journal of Botany 88: 2252-2258.

National Agriculture Pest Information System. 2004. http://ceris.purdue.edu/napis/pests/pls/index.html

Pellett, M. 1966. Purple loosestrife, colorful honey plant. American Bee Journal 106: 450-451.

Pellett, M. 1977. Purple loosestrife spreads down river. American Bee Journal 117: 214-215.

Rachich, J., & R. J. Reader. 1999. An experimental study of wetland invisibility by purple loosestrife (*Lythrum salicaria*). Canadian Journal of Botany 77: 1499-1503.

Radford, A. E., H. E. Ahles, & C. R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. University of North Carolina Press, Chapel Hill. 1,183 pp.

Rawinski, T. J. 1982. The ecology and management of purple loosestrife (*Lythrum salicaria* L.) in central New York. M. S. thesis. Cornell University, Ithaca, NY. 88 pp.

SAS Institute, 1985. SAS User's Guide: Statistics, Release 9.1. SAS Institute, Cary, NC.

Shamsi, S. R. A., & F. H. Whitehead. 1974. Comparative ecophysiology of *Epilobium hirsutum* and *Lythrum salicaria* L. General biology, distribution, and germination. Journal of Ecology 62: 279-290.

Stuckey, R. L. 1980. Distributional history of *Lythrum salicaria* (purple loosestrife) in North America. Bartonia 47: 3-20.

Teale, E. W. 1982. Stems beyond counting, flowers unnumbered. Audubon 84(4): 38-43.

Thompson, D. Q., R. L. Stuckey, & E. B. Thompson. 1987. Spread, impact, and control of purple loosestrife (*Lythrum salicaria*) in North America. U.S. Fish and Wildlife Service Research Report 2. 55 pp.

Townsend, J. F. 2005. Natural heritage resources of Virginia: rare plants. Natural Heritage Technical Report 05-08. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 54 pp.

Treburg, M. A,. & B. C. Husband. 1999. Relationship between the abundance of *Lythrum salicaria* (purple loosestrife) and plant species richness along the Bar River, Canada. Wetlands 19: 118-125.

Welling, C. H., & R. L. Becker. 1990. Seed bank dynamics of *Lythrum salicaria* L.: implications for control of this species in North America. Aquatic Botany 38: 303-309.

Wiebe, A. P., A. B. Cortilet, J. J. Obrycki, & M. D. K. Owen. 2001. Releases of natural enemies of purple loosestrife (*Lythrum salicaria* L.), in Iowa wetlands. Journal of the Kansas Entomological Society 74: 106-109.

Wilcox, D. A. 1989. Migration and control of purple loosestrife (*Lythrum salicaria* L.) along highway corridors. Environmental Management 13: 365-370.

Banisteria, Number 25, 2005

The Virginia Species of *Banasa,* Three Decades Later (Heteroptera: Pentatomidae)

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ABSTRACT

The five species of the pentatomid genus *Banasa* known to occur in Virginia are reviewed in light of knowledge accrued during the past three decades, with emphasis on in-state distribution and improved criteria for species recognition. A key for their identification is provided, as well as a distribution map for *Banasa dimidiata.* The occurrence of two allopatric color morphs of this species is noted and related to distribution of the phenomenon elsewhere in the species' range.

Key words: Heteroptera, Pentatomidae, *Banasa*, Virginia.

The pentatomoid bugs of Virginia were the subject of a faunistic synopsis published several decades ago (Hoffman, 1971), a survey replete with all of the shortcomings of most initial treatments. During the 35 following years of in-state field work a number of species were added to the known Virginia fauna, numerous refinements of distribution accomplished, and enough material accumulated to enable taxonomic corrections and improvements. Some of this upgrading has already been published in earlier numbers of *Banisteria* (Hoffman, 1994, 2002).

Among the weak spots in my 1971 account was the treatment of the genus *Banasa,* uncritically extracted from the manual by W. S. Blatchley (1926), the contemporaneous authoritative source. Because Blatchley's account of the eastern species of *Banasa* was itself compiled from faulty antecedents, my 1971 key perpetuated the problems. In the first formal "revision" of the Nearctic species of this genus, Thomas & Yonke (1981a) established that the pioneer work on these bugs was flawed by its reliance on color and other external parameters now known to be highly variable and largely unreliable for species recognition. Although the text of their paper was notably condensed, it established structure of the male pygophore as the basis for reliable identification of species. With this improved insight I now review the status of several Virginia species to partially atone for the misinformation proffered as genuine in 1971.

Key to Virginia species of *Banasa*
(Adapted from Thomas & Yonke, 1981a)

1. Dorsum green, with prominent white spots at basal angles of scutellum .... *euchlora*
– Dorsum variable in color, scutellum without white spots at basal angles.. 2
2. Pronotum, scutellum, and corium of hemelytra concolorous, usually gray or light grayish-brown, with apex of the scutellum white; abdomen pale with four irregular rows of dark markings....................... *sordida*
– Pronotum bicolored, anterior half lighter than posterior; abdomen concolorous with dorsum, without four series of black marks... 3
3. Rostrum extending as far as posterior edge of first visible abdominal segment............................ *packardi*
– Rostrum not exceeding posterior side of rear coxae.....4
4. Inner edge of pygophore produced into a slender acuminate projection (Fig. 2); metapleura with black spot at the stigma .... *dimidiata*
– Inner edge of pygophore forming a broad inward flange with denticulate distal edge (Fig. 1); metapleura without black spot at stigma .... *calva*

Banasa calva (Say) (Fig. 1)

My account of this species (1971: 50) was very superficial, and reported it only from the cities of Norfolk and Newport News, without the examination of specimens. *Banasa calva* is now known to be the most

widespread and frequently collected member of the genus in Virginia.

As determined on the basis of the preceding key characters, *B. calva* is represented in the VMNH collection from Accomack, Augusta, Bath, Brunswick, Charles City, Charlotte, Dinwiddie, Essex, Floyd, Franklin, Greensville, Halifax, Hanover, Henry, Isle of Wight, King & Queen, Mecklenburg, Northampton, Patrick, Pittsylvania, Prince William, Richmond, Southampton, Stafford, Surry, Sussex, and Tazewell counties, and the cities of Chesapeake, Richmond, Suffolk, and Virginia Beach. The majority of the collection sites lie east of the Blue Ridge, but the species occurs sporadically in western Virginia, as high as 3800 feet (1152 m) on Warm Springs Mountain in Bath County.

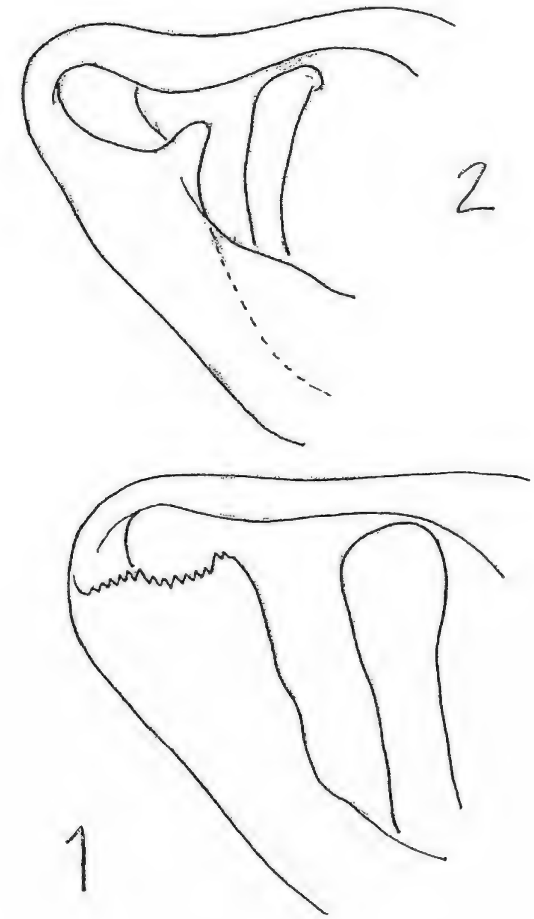
Banasa dimidiata (Say) (Figs. 2, 3)

This species was recorded from 13 counties and two cities in my 1971 account, but some of those records were based on misidentified specimens of *B. calva*, and only the following localities (based on VMNH specimens) are reliable:

Alleghany, Dickenson, Dinwiddie, Fauquier, Floyd, Franklin, Grayson, Halifax, Isle of Wight, Montgomery, Northampton, Patrick, Russell, Smyth, Stafford, Sussex, and Tazewell counties, and the cities of Richmond, Suffolk, and Virginia Beach. While less often collected than *B. calva*, this species is dispersed over the state, and extends from sea level up to about 5000 feet (1515 m) on Mount Rogers.

There is evident in-state geographic variation in color pattern, which closely reflects that noted by Thomas & Yonke (1981a) for the overall range of the species: "Specimens from northern and western U.S. have dorsal surface of head red or trimmed with red and strongly darkly punctate; specimens from southeastern U.S. have head greenish or yellowish, punctations concolorous with surface." As indicated by solid dots on the map (Fig. 3), specimens from the Piedmont and Coastal Plain areas of Virginia represent the latter condition, being generally pallid with the head and anterior half of the pronotum concolorous, often nearly white.

At elevations above 3000 feet (909 m) in the mountains, the head is distinctly reddish, with the large, coarse, punctures black, exactly as described in the preceding paragraph. Such specimens are at hand from Buffalo Mountain, Floyd Co.; Warm Springs Mountain, Alleghany Co.; Garden Mountain, Tazewell Co.; Clinch Mountain, Russell Co.; White Top Mountain and Mount Rogers, Grayson Co., as indicated by square symbols on Fig. 3.



Figs. 1, 2. Male pygophore of two species of *Banasa*, oblique caudomesal aspect, showing modification of inner edge. The difference in shape of the parameres is illusory, owing to different aspects of these appendages (more edgewise in Fig. 2). Fig. 1. *Banasa calva* (Say). Fig. 2. *Banasa dimidiata* (Say).

This apparently boreal form extends southward into the mountains of North Carolina, as shown by specimens in the North Carolina State University insect collection from Highlands, Grandfather Mountain, Linville Falls, Mount Mitchell, and Banner Elk, all localities above 4000 feet (1212 m) in elevation. Almost certainly it will be found in Georgia and Tennessee.

That the gene for this variation can express itself occasionally in lowland populations is evident from single specimens with reddish heads from Halifax County and False Cape State Park, City of Virginia Beach. Essential allopatry of the two color forms suggests the classical geographic subspecific relationship, although I am unable to see any differences in pygophore structure. Details of cytogenetics in this species were discussed fully in a later

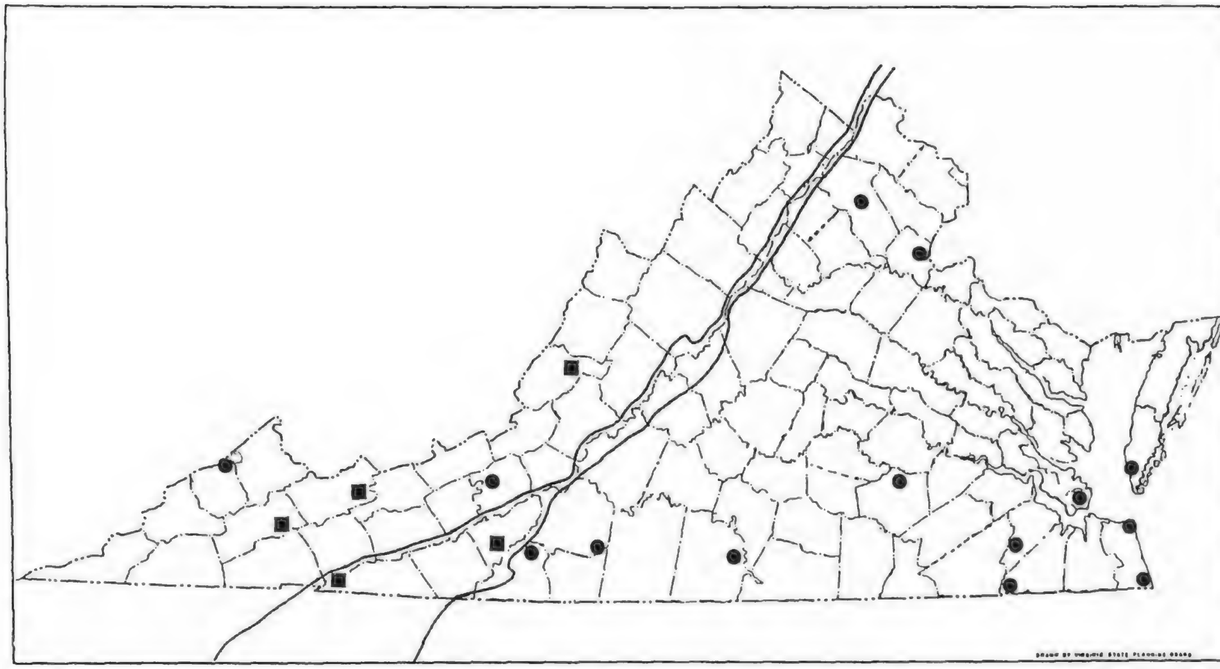


Fig. 3. Distributional records for *Banasa dimidiata* in Virginia. The ■ symbol indicates localities at which the montane color phase with reddish head has been collected, localities for the pale lowland form are indicated by the ●.

paper by Thomas & Yonke (1981b) which suggests that the paler, lowland form has one pair of chromosomes fewer (2n = 12) than the widespread northern variety with reddish head (2n = 14).

Formalizing this relationship taxonomically would require restriction of the trinomial *Banasa d. dimidiata* to the southeastern subspecies, as Say's *Pentatoma dimidiata* was based on specimens from "Georgia and East Florida".

Froeschner (1988) proposed to revive the spelling *dimiata* used in Say's original description, on the premise that the name *dimidiata* used by LeConte (1859) and almost all subsequent authors was an unjustified emendation. The most recent edition of the International Code of Zoological Nomenclature (1999) treats the subject of original spellings at some length, in general mandating their use (Articles 32 and 33). Aside from the information in the name itself favoring inadvertancy in Say's published spelling (*dimiata* means nothing in any classical language, whereas *dimidiatus* denotes *"half"* or *"divided"*, a possible allusion to the bicolored pronotum of this species), the Code provides exemption from strict observation in cases of long and extensive ("prevailing") usage (Article 33.2 3 1). Whether LeConte's emended spelling was justifiable or not, 130 years of consistent usage of *dimidiata* certainly justifies its preservation.

Banasa sordida (Uhler)

This species, described without reference to any locality, was recorded by Van Duzee (1917) from "Virginia" without further specification, and I have not been able to trace the basis for the record. Blatchley (1926) defined a wide distribution across northern United States and Canada, with extensions southward through the Rockies and down the East Coast to the District of Columbia and Virginia. Brimley (1938) cited two localities in the Piedmont of North Carolina. Thomas & Yonke (1981a) stated "Entire U.S., northern Mexico, and southern Canada" for the distribution. Froeschner (1988) listed 14 states and provinces (mostly encompassed by Blatchley's statement of range), thus excluding much of southeastern United States.

My brief treatment of the species in 1971 summarized previous knowledge and predicted that *B. sordida* would eventually be discovered in Virginia, but several decades were to pass before this confidence was vindicated. VMNH now has two specimens of the species: *City of Galax*: at motel lights, intersection of Rts. 58 and 89, 14 June 2004, S. M. Roble. *Prince Edward Co.:* Hampden-Sydney College, 5 October 1992, P. Bangle. Considering the large number of pentatomid bugs collected throughout Virginia during the past several decades, this marginal

representation of *B. sordida* may reflect actual scarcity of the species rather than undercollecting. The NCSU collection contains only a few specimens from two localities in that state: Wake County (1); Morehead City (5), also possibly indicative of scarcity south of Virginia.

Banasa euchlora (Say)

This beautiful insect is readily distinguished from other members of its genus (and all other Virginia pentatomids) by the uniform jade green color, with basal angles of the scutellum ivory white and claval areas of the hemelytra finely irrorated with white. In 1971 I recorded it from only the counties of Fluvanna, Henrico, and Montgomery, imparting the impression of scarcity in the state. Subsequent collections provide a much better picture of its distribution; VMNH has 33 specimens from Accomack, Appomattox, Dinwiddie, Fluvanna, Franklin, Halifax, Isle of Wight, Montgomery, Northampton, Nottoway, and Pulaski counties, and the cities of Roanoke, Richmond, Suffolk, and Virginia Beach. The paucity of records for western Virginia is noteworthy.

Collection dates range from late May to early October. The species seems to be attracted to UV lights more often than other local pentatomids, sometimes in numbers (not all of the material so trapped was retained for the collection or tabulated).

Banasa packardi Stål

Originally described from North Carolina, this species is reputed to inhabit the coastal region from New Jersey to Florida. Despite extensive collecting efforts in recent years in southeastern Virginia and the "Eastern Shore", there are still no specimens known to me from Virginia despite the statement by Thomas & Yonke (1981a) "...Virginia south to Mexico City..." The preferred host plant is *Juniperus virginiana*, which thus may be targeted for particular attention during field activities in our coastal areas.

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LITERATURE CITED

Blatchley, W. S. 1926. Heteroptera or True Bugs of Eastern North America, with Especial Reference to the Faunas of Indiana and Florida. Nature Publishing Company, Indianapolis. 1,116 pp.

Brimley, C. S. 1938. The Insects of North Carolina. Being a List of the Insects of North Carolina and Their Near Relatives. North Carolina Department of Agriculture, Raleigh. 560 pp.

Froeschner, R. C. 1988. Family Pentatomidae. Pp. 544-597 *In* T. J. Henry & R. C. Froeschner (eds.), Catalog of the Heteroptera, or True Bugs, of Canada and the Continental United States. E. J. Brill, Leiden, New York, Kobenhavn, Koln.

Hoffman, R. L. 1971. Shield bugs (Hemiptera; Scutelleroidea: Scutelleridae, Corimelaenidae, Cydnidae, Pentatomidae). The Insects of Virginia: No. 4. Research Division Bulletin 67, Virginia Polytechnic Institute and State University, Blacksburg. 61 pp.

Hoffman, R. L. 1994. Additions and emendations to the Virginia fauna of "True Bugs" (Heteroptera: Cydnidae, Scutelleridae, Pentatomidae). Banisteria 3: 15-19.

Hoffman, R. L. 2002. New records for stink bugs in Virginia (Heteroptera: Scutelleridae, Pentatomidae). Banisteria 19: 12-16.

LeConte, J. L. 1859. The Complete Writings of Thomas Say on the Entomology of North America. Two volumes Bailliere Brothers, New York 412 and 814 pp.

Say, T. 1831-32. Descriptions of new species of heteropterous Hemiptera of North America. New Harmony, Indiana. 39 pp.

Thomas, D. B., & T. R. Yonke. 1981a. A review of the Nearctic species of the genus *Banasa* Stål (Hemiptera: Pentatomidae). Journal of the Kansas Entomological Society 54: 233-248.

Thomas, D. B., & T. R. Yonke. 1981b. Evolutionary cytogenetics of *Banasa* Stål (Hemiptera: Pentatomidae). Pp. 103-121 *In* M. W. Stock (ed.), Application of Genetics and Cytology in Insect Systematics and Evolution. Proceedings of a Symposium, National Meeting, Entomological Society of America, Atlanta, December 1-2, 1980. University of Idaho, Moscow.

Van Duzee, E. P. 1917. Catalogue of the Hemiptera of America north of Mexico, excepting the Aphididae, Coccidae, and Aleurodidae. University of California Publications in Entomology 2. 912 pp.

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Observations on Blainville's Beaked Whales, *Mesoplodon densirostris* (Blainville, 1817), at Poor Man's Canyon, Virginia

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ABSTRACT

A group of three Blainville's Beaked Whales (*Mesoplodon densirostris*) was observed in the Atlantic Ocean at Poor Man's Canyon off the coast of Virginia. These sightings apparently are the first documented at-sea records of this species from Virginia's offshore waters.

Key words: Atlantic Ocean, *Mesoplodon*, Virginia, whale.

INTRODUCTION

On 17 August 1996, while conducting a public birdwatching excursion into Virginia's pelagic waters aboard the headboat *Judith M*, we observed a group of three whales of the genus *Mesoplodon* that we identified as Blainville's Beaked Whales (*M. densirostris*), also known as Dense-beaked Whale, Atlantic Beaked Whale, or Tropical Beaked Whale. The whales were located at 37° 49' 30"N, 74° 06' 30"W and were studied at 1240 EDT for just under five minutes at a distance of some 400–500 m through Zeiss 10 x 40 and 7 x 42 binoculars. Water temperature was 20.8° C, water depth over the canyon approximately 400 m, and the wind-sea state judged to be Force 0 to 1 on the Beaufort Scale. Air temperature was not recorded, and no seawater frontal activity was observed in the vicinity. The whales sounded as we approached them and could not be photographed. The only other cetaceans noted in the immediate vicinity included several dozen Risso's Dolphins (*Grampus griseus*) and Atlantic Bottlenose Dolphins (*Tursiops truncatus*).

The identification to genus was made carefully in order to rule out the superficially similar Cuvier's Beaked Whale (*Ziphius cavirostris*). The relatively long, distinct rostrum of the two larger animals was of a shape consistent with that of *Mesoplodon* but not with that of *Ziphius*, which is very deep basally, especially in the male, and tapers to a blunt tip, with little in the way of a distinct "beak" (hence the local name "Goosebeak").

We judged the whales' lengths to be in the range of 4 to 5 m, with two animals clearly larger than the third and one of the two larger animals slightly or noticeably larger than the other. Coloration was dark gray to somewhat paler gray dorsally, although coloration was difficult to determine precisely, and under transient light conditions, a cast of bluish or brownish sometimes appeared. The whales' ventral surfaces were not seen apart from the underside of the lower jaw on two animals. The largest individual appeared to be slightly darker than the next largest, and the largest showed a dark blotch surrounding the eye. It also appeared to be mottled with paler scars or scratches, though distance precluded determination of the precise appearance of these marks. The next-largest whale bore a strikingly pale lower jaw, with the distal two-thirds of the upper jaw similarly pale. All three showed a small, triangular dorsal fin set back about two-thirds of the way down the back. The dorsal fin appeared markedly darker in the larger animals, and on one occasion the larger animals' central back appeared to bear a very narrow

ridge of darker pigment along the spine. The shape of the dorsal fin was nearly that of an equilateral triangle in the smallest individual, which was not seen especially well, but slightly more falcate (curved along the posterior edge) in the larger whales.

The largest whale surfaced several times between the boat and the other two whales, bringing its rostrum and head well out of the water at a sharp angle (about 45 degrees) and bringing it down abruptly; the surfacing of the other two whales was less conspicuous, although the head of the next-largest whale was seen well on one occasion. When the largest animal commenced its "roll," we were twice able to see a high arch in the lower jaw near the corner of the mouth, with the arch extending above the level of the eye and nearly to the level of the upper jaw. No other Atlantic *Mesoplodon* shows this exaggerated bulge of the lower jaw.

DISCUSSION

Identification

The high "crested" mandible with a prominent arch (sometimes with barnacle-covered tooth at just posterior of the mid-jaw) is a diagnostic character of adult male Blainville's Beaked Whale, and the roll behavior we observed was strongly suggestive of the species (Jefferson et al., 1993; Carwardine, 1995; Ritter, 1999; Tove, 2000; Cresswell & Walker, 2001). The pigmentation of the second-largest animal was suggestive of an adult female Blainville's Beaked Whale (Carwardine, 1995). Maximum recorded lengths are 4.7 m in both sexes (Ward, 2001), which accords with our estimates of size. Group size is typically between two and nine animals (Jefferson et al., 1993; Ritter & Brederlau, 1999), with a mean of 3.4 animals per group (Ritter & Brederlau, 1999), also consistent with our observation.

Other local at-sea reports of *Mesoplodon*

We have seen this species only once subsequently, on 30 May 1998, off Hatteras, North Carolina (Patteson & Brinkley, unpubl. data). Off this port, in the deep Continental Slope waters (>1000 m depth) crossed by the Gulf Stream, we have routinely observed herds of Cuvier's Beaked Whales between 1981 and 2005 and are familiar with their behavior and identification, which is feasible at considerable distances, particularly when the pale-headed males are present. We also see *Mesoplodon* once or twice annually, but these whales rarely remain at the surface long enough to be identified.

In the wider area of the mid-Atlantic states, there is photographic documentation of three probable Blainville's Beaked Whales from an area south of Hudson Canyon (off New Jersey) on 9 June 1979; this was the only record of the genus during the 14 months of survey work of the Cetacean and Turtle Assessment Program (CeTAP) 1979-1980 (CeTAP, 1982). This would appear to be the only other published at-sea record of the species from the mid-Atlantic, although there is an unpublished sight record of the genus from 30 May 1999 off Hatteras, North Carolina (M. Tove, *in litt.*). None of the 21 beaked whale contacts (a category that includes both *Ziphius* and *Mesoplodon*) of the more recent National Marine Fisheries western North Atlantic stock assessment studies were of individuals identified to species (Blaylock et al., 1995). Moreover, none of those contacts were made in Virginia's offshore waters, from which apparently no at-sea records of *Mesoplodon* have previously come (Rowlett, 1980; Blaylock, 1985). In Virginia waters, the only offshore mesoplodont record known to us is a recent record of four to five adult Sowerby's Beaked Whales (*M. bidens*) seen on 10 July 1998 some 77 nautical miles east of the Virginia–North Carolina border by T. Pusser (pers. comm.) during a line-transect survey on the vessel *Relentless*. This species would seem to be the most easily confused at sea with Blainville's in the Atlantic, and it should be kept in mind when studying a mesoplodont off the mid-Atlantic states, even though Pusser's record represents one of only two records from waters south of Cape Cod, the other being from the Gulf of Mexico, which is considered extralimital (Bonde & O'Shea, 1989).

Global and regional distribution

Blainville's Beaked Whale, the most widely distributed of the mesoplodonts, is apparently an uncommon resident of warm waters around the world. It is the only member of its genus found on both sides of the equator (Leatherwood et al., 1976; Leatherwood & Reeves, 1983; Meade, 1989; Carwardine, 1995; Pitman, 2002). Through 1971, the species was known only through 18 strandings worldwide (Beharse, 1971), but since that time many more strandings and at-sea records have come to light. The distribution away from the western North Atlantic is deduced from a handful of single records from Britain (Herman et al., 1994), Portugal, Spain, Madeira, Japan, California, and Australia (Rice, 1998) and New Brunswick, Canada (McAlpine & Rae, 1999). Other sightings have been reported from Hawaii (where the species is now known to be relatively common), Brazil, Chile, Taiwan, Midway Island, Mauritius, the Seychelles, and South

Africa (Mead, 1989; Rice, 1998) as well as New Zealand (Baker & van Helden, 1999).

In the western North Atlantic, where the species is most often recorded (MacLeod 2000), Blainville's Beaked Whale is known to occur from Atlantic Canada to Florida, the Bahamas, and into the Gulf of Mexico (Mead, 1989). The most recent estimate (1998 data) of beaked whale numbers in the western North Atlantic stock is 3,196: 2,600 in the Atlantic off the northeastern United States, and 596 in the Atlantic off the southeastern United States, a number acknowledged to have a wide error margin (Waring et al., 2001).

Data from research vessels show that they rarely made contact with beaked whales in the past, and very few mesoplodonts have ever been critically identified (Pitman, 2002). In the Gulf of Mexico, for instance, the first systematic surveys of cetaceans in deep waters—by the National Oceanic and Atmospheric Administration's (NOAA) research vessel *Oregon II* in 1991–1994—did not distinguish *Mesoplodon* from *Ziphius* in their data (Davis et al., 1994). Likewise, the GULFCET projects documented no Blainville's Beaked Whales, despite multiple contacts with ziphiids (Davis & Fargion, 1996). The species is known in the Gulf of Mexico by two stranding records and one probable observation at sea (Jefferson et al., 1992; Hansen et al., 1995). In the western North Atlantic, the Bahamas Marine Mammal Survey, an activity of the Center for Whale Research, has found the species to be common off Great Abaco Island, with over 60 individuals photographically identified, 16 of those revealing inter-year and intra-year matches, including mother/calf pairs (Claridge & Balcomb, 1995).

Stranding records

The only mass strandings of Blainville's Beaked Whale have been recorded in the Bahamas on 5 March 1998 (n = 3; Balcomb & Claridge, 2001) and on 15 March 2000 (n = 3, plus 2 unidentified *Mesoplodon*; Anonymous, 2001; Balcomb & Claridge, 2001). Most records of this species in the western North Atlantic away from the Bahamas come from stranding events involving single animals. We have located data on eight strandings of single individuals in the Atlantic coast of North America between Nova Scotia and Florida in the literature, including a 1973 specimen record from Assawoman Island, Virginia (Potter, 1979). We are aware of at least six other unpublished reports on file with the Smithsonian Institution in its database of stranded marine mammals (D. Allen, pers. comm.). In Virginia, Blainville's Beaked Whale would appear to be an uncommon visitor: the majority of Virginia's few published *Mesoplodon* stranding records (n = 3, 60%) are of *M. europaeus* (Potter 1979, 1991; Linzey, 1998). Strandings, however, do not necessarily reflect relative abundance of various species in proximal pelagic waters in any case, and there are several unpublished Virginia strandings of mesoplodonts for which data were not available to us.

Reasons for strandings are usually not apparent, but in one case, ingestion of plastic debris has been implicated in the death of a Blainville's Beaked Whale (Secchi & Zarzur, 1999). Off the northeastern coast of the United States, 46 fishery-related mortalities were observed in the pelagic drift gillnet fishery between 1989 and 1998: 24 Sowerby's, 4 True's, and 17 unidentified beaked whales (Waring et al., 2001). In September 2002, one Blainville's Beaked Whale was apparently killed during a naval exercise conducted around Gran Canaria, Spain (V. Martin, pers. comm.), and another three to five Blainville's stranded alive (one of these died) due to injuries inflicted by Low Frequency Active Sonar (LFAS) in use by U. S. Navy vessels in the area on 15 March 2000 (Anonymous, 2001; Balcomb & Claridge, 2001).

CONCLUSIONS

The location of our Blainville's Beaked Whale sight record in Virginia waters is unsurprising, given that surveys of marine mammals in the mid-Atlantic have noted a strong tendency for cetaceans to be distributed along the edge of the Continental Shelf, centered on the 1,000-m depth contour (Edel et al., 1981; Blaylock et al., 1995) and given the preference of this genus for deep water in general (Pitman, 2002). The area of Poor Man's Canyon, much like that of the larger Baltimore Canyon, has historically produced multiple contacts with squid-eating species such as Risso's Dolphin (*Grampus griseus*), Northern Bottlenose Whale (*Hyperoodon ampullatus*), and pilot whale species (*Globicephala*) (pers. obs.; Rowlett, 1980; T. Pusser, pers. comm.), so that the presence of *Mesoplodon* here, a genus known to eat squid (Mead, 1989; Pitman, 2002; MacLeod et al., 2003), is logical.

ACKNOWLEDGMENTS

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LITERATURE CITED

Anonymous. 2001. Joint interim report Bahamas marine mammal stranding event of 15-16 March 2000. Unpublished report released by the U.S. Department of Commerce and the Secretary of the Navy. 59 pp. Available at <http://www.nmfs.noaa.gov/prot_res/overview/Interim_Bahamas_Report.pdf>.

Balcomb, K. E., III, & D. E. Claridge. 2001. A mass stranding of cetaceans caused by naval sonar in the Bahamas. Bahamas Journal of Science 2: 2-12.

Baker, A. N., & A. L. Van Helden. 1999. New records of beaked whales, genus *Mesoplodon*, from New Zealand (Cetacea: Ziphiidae). Journal of the Royal Society of New Zealand 29: 235-244.

Blaylock, R. A. 1985. The marine mammals of Virginia, with notes on identification and natural history. Virginia Institute of Marine Science Education Series No. 35 (Publication VSG-85-05). College of William and Mary, Williamsburg, VA. 118 pp.

Blaylock, R. A., J. W. Hain, L. J. Hansen, D. L. Palka, & G. T. Waring. 1995. U. S. Atlantic and Gulf of Mexico marine mammal stock assessments. National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SEFSC-363. 211 pp.

Bonde, R. K., & T. J. O'Shea. 1989. Sowerby's beaked whale (*Mesoplodon bidens*) in the Gulf of Mexico. Journal of Mammalogy 70: 447-449.

Carwardine, M. 1995. Whales, Dolphins, and Porpoises. Dorling Kindersley, London. 256 pp.

Cetacean and Turtle Assessment Program [CeTAP]. 1982. A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the U.S. outer continental shelf. Cetacean and Turtle Assessment Program, University of Rhode Island. Final Report #AA551-CT8-48 to the Bureau of Land Management, Washington, DC. 538 pp.

Claridge, D. E., & K. C. Balcomb. 1995. Photo–identification of dense–beaked whales (*Mesoplodon densirostris*) in the north-eastern Bahamas. P. 23 *In* Abstracts of the Eleventh Biennial Conference on the Biology of Marine Mammals, Orlando, December 1995.

Cresswell, G., & D. Walker. 2001. Whales and Dolphins of the European Atlantic, the Bay of Biscay, and the English Channel. Wild Guides, Ltd. Hampshire, England. 56 pp.

Davis, R., G. Scott, B. Würsig, W. Evans, G. Fargion, L. Hansen, K. Mullin, N. May, T. Leming, B. Mate, J. Norris, & T. Jefferson. 1994. Distribution and abundance of marine mammals in the north-central and western Gulf of Mexico: Final Report. OCS Study #MMS 94-0003. Texas Institute of Oceanography and the National Marine Fisheries Service. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Hansen, L. J., K. D. Mullin, & C. L. Roden. 1995. Estimates of cetacean abundance in the northern Gulf of Mexico from vessel surveys. Southeast Fisheries Science Center, Miami Laboratory, Contribution No. MIA-94/95-25. 9 pp.

Herman J. S., A. C. Kitchener, J. R. Baker, & C. Lockyer 1994. The most northerly record of Blainville's beaked whale, *Mesoplodon densirostris*, from the eastern Atlantic. Mammalia 58: 657-661.

Houston, J. 1989. Status of Blainville's beaked whale, *Mesoplodon densirostris*, in Canada. Canadian Field Naturalist 104: 117-120.

Jefferson, T. A., S. Leatherwood, & M. A. Webber. 1993. FAO Species Identification Guide, Marine Mammals of the World. Food and Agriculture Organization of the United Nations, Rome. 320 pp.

Jefferson, T. A., S. Leatherwood, L. K. M. Shoda, & R. L. Pitman. 1992. Marine Mammals of the Gulf of Mexico: A Field Guide for Aerial and Shipboard Observers. Texas A&M University Printing Center, College Station, TX. 92 pp.

Leatherwood, S., & R. R. Reeves. 1983. The Sierra Club Handbook of Whales and Dolphins. Sierra Club Books, San Francisco, CA. 302 pp.

Leatherwood, S., D. K. Caldwell, & H. E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic. A guide to their identification. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Report NMFS Circular 396. 176 pp.

Lee, D. S., R. B. Funderburg, & M. K. Clark. 1982. A distributional survey of North Carolina mammals. Occasional Papers of the North Carolina Biological Survey 1982-10. North Carolina Museum of Natural

History, Raleigh. 70 pp.

Linzey, D. W. 1998. The Mammals of Virginia. McDonald & Woodward Publishing Company, Blacksburg, VA. 459 pp.

MacLeod, C. D. 2000. Review of the distribution of *Mesoplodon* species (order Cetacea, family Ziphiidae) in the North Atlantic. Mammal Review 30: 1-8.

MacLeod, C. D., M. B. Santos, & G. J. Pierce. 2003. Review of data on diets of beaked whales: Evidence of niche separation and geographic segregation. Journal of the Marine Biological Association of the United Kingdom 83: 651-665.

McAlpine, D. F., & M. Rae. 1999. First confirmed reports of beaked whales, cf. *Mesoplodon bidens* and *M. densirostris* (Ziphiidae), from New Brunswick. Canadian Field Naturalist 113: 293-295.

Mead, J. G. 1989. Beaked whales of the genus *Mesoplodon*. Pp. 349-430 *In* S. H. Ridgway & R. Harrison (eds.), Handbook of Marine Mammals, Vol. 4: River Dolphins and the Larger Toothed Whales. Academic Press, London. 442 pp.

Nicolas, J., A. Williams, & G. Repucci. 1993. Observations of beaked whales (*Mesoplodon* spp.) in the western North Atlantic Ocean. Proceedings of the Tenth Biennial Conference on the Biology of Marine Mammals, November 11-15, 1993, Galveston, TX (Abstract).

Pitman, R. L. 2002. Mesoplodont whales. Pp. 738-742 *In* W. F. Perrin, B. Würsig, & J. G. M. Thewissen (eds.), Encyclopedia of Marine Mammals. Academic Press, San Diego, CA.

Potter, C. W. 1979. Mammals – The marine fauna. Pp. 595-602. *In* D. W. Linzey (ed.), Proceedings of the Symposium on Endangered and Threatened Plants and Animals of Virginia. Center for Environmental Studies, Virginia Polytechnic Institute and State University, Blacksburg, VA.

Potter, C. W. 1991. Marine mammals. Pp. 603-607. *In* K. Terwilliger (coord.), Virginia's Endangered Species. McDonald & Woodward Publishing Company, Blacksburg, VA.

Reynolds, J. E., III, & D. K. Odell (eds.). 1991. Marine Mammal Strandings in the United States. Proceedings of the Second Marine Mammal Stranding Workshop Miami, Florida, December 30, 1987. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Report NMFS 98. National Technical Information Service, Springfield, VA. 157 pp.

Rice, D. W. 1998. Marine Mammals of the World: Systematics and Distribution. Society for Marine Mammalogy, Special Publication Number 4 (D. Wartzok, ed.). Lawrence, KS. 4,231 pp.

Ritter, F., & B. Brederlau. 1999. Behavioural observations of dense beaked whales (*Mesoplodon densirostris*) off La Gomera, Canary Islands (1995-1997). Aquatic Mammals 25: 55-61.

Rowlett, R. A. 1980. Observations of marine birds and mammals in the northern Chesapeake Bight. U. S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-80/04. 87 pp.

Secchi, E. R., & S. Zarzur. 1999. Plastic debris ingested by a Blainville's beaked whale, *Mesoplodon densirostris*, washed ashore in Brazil. Aquatic Mammals 25: 21-24.

Tove, M. H. 2000. Guide to the Offshore Wildlife of the Northern Atlantic. University of Texas, Austin. 250 pp.

Ward, H. K. 2001. Beaked whales. <http://www.cetacea.org/whales.htm>.

Waring, G. T., J. M. Quintal, & S. L. Schwartz (eds.). 2001. U. S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2001. National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NE-168. <http://www.nefsc.noaa.gov/nefsc/publications/tm/tm168/index.htm>.

Webster, W. D., P. D. Goley, J. Pustis, & J. F. Gouveia. 1996. Seasonality in cetacean strandings along the coast of North Carolina. Brimleyana 23: 41-51.

Shorter Contributions

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VOCAL MIMICRY OF BROAD-WINGED HAWK BY BLUE JAY—The Blue Jay (*Cyanocitta cristata*) is a well-known vocal mimic of the Red-shouldered Hawk (*Buteo lineatus*), Red-tailed Hawk (*Buteo jamaicensis*), and several other predatory birds in eastern North America (Atkins, 1987; Hailman, 1990; Phillips, 1993; Tarvin & Woolfenden, 1999). At least five hypotheses have been proposed to explain jay mimicry of raptor vocalizations but unequivocal evidence for a specific function is still lacking (Hailman, 1990; Tarvin & Woolfenden, 1999). Future investigation of this widespread phenomenon will benefit from careful documentation of the geographic and temporal patterns of jay mimicry and raptor distribution.

Here I report the first well-documented account of the Blue Jay mimicking the Broad-winged Hawk (*Buteo platycercus*). On 13 June 2002, I heard what I thought was the whistle call of a Broad-winged Hawk in the forest canopy at my campsite on Big Santeetlah Creek, Graham County, North Carolina (35° 20.7' N, 83° 57.9' W; 840 m above sea level = asl). After a few minutes, I located the source of the call, a pair of Blue Jays that had been frequenting the campsite during the preceding week. This fact was confirmed a few minutes later when the jays flew across a small clearing and one of them gave the "hawk" whistle call several more times. John Gerwin, Rebecca Browning, and I heard jays mimic a Broad-winged Hawk at the same site on the morning of 15 June, and I tape-recorded a short sequence of similar jay calls there at 0800 h on 17 June (Fig. 1). The behavioral context of the vocal mimicry was unknown in all three cases.

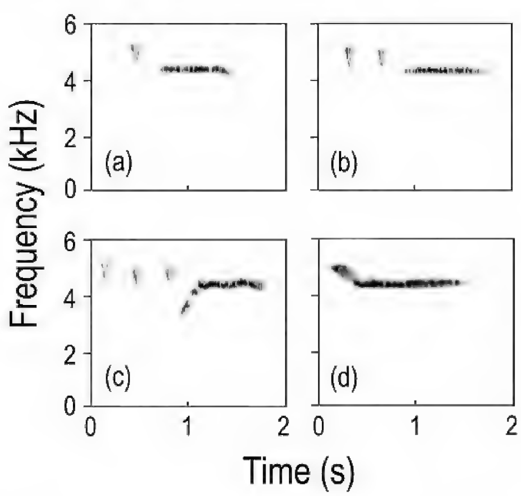

Fig. 1. Audio spectrographs (a-c) of three consecutive whistle-calls of a Blue Jay mimicking a Broad-winged Hawk (Graham County, North Carolina; 17 June 2002), and (d) a whistle-call of a Broad-winged Hawk (Cumberland County, Tennessee; 8 July 2002).

Broad-winged Hawks occur at relatively low densities as a summer resident in the Big Santeetlah Creek watershed (620-1679 m asl), but none was known to be in the immediate vicinity when the jays called. With the exception of single sightings of a Red-tailed Hawk and an unidentified *Accipiter*, this was the only hawk I observed in the Santeetlah Creek watershed (Graves et al., 2002) during 91 days of fieldwork over ten consecutive breeding seasons (9-24 June 1995-2004). This observation suggests that breeding Blue Jays may only mimic raptors that are locally present regardless of previous experience with other raptor species encountered during the non-breeding season.

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LITERATURE CITED

Atkins, A. 1987. Blue Jay imitates Osprey. Oriole 52: 48.

Graves, G. R., C. S. Romanek, & A. Rodriguez Navarro. 2002. Stable isotope signature of philopatry and dispersal in a migratory bird. Proceedings of the National Academy of Sciences USA 99: 8096-8100.

Hailman, J. P. 1990. Blue Jay mimics Osprey. Florida Field Naturalist 18: 81-82.

Phillips, J. D. 1993. Blue Jay vocalization resembles Fish Crow. Redstart 60: 53.

Tarvin, K. A., & G. E. Woolfenden. 1999. Blue Jay (*Cyanocitta cristata*). Pp. 1-31 *In* A. Poole & F. Gill (eds.), The Birds of North America. Academy of Natural Sciences, Philadelphia, PA and American Ornithologists' Union, Washington, DC.

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ALBINISM IN AMERICAN BULLFROG (*RANA CATESBEIANA*) TADPOLES FROM VIRGINIA— Albino *Rana catesbeiana* adults and tadpoles have been reported from a number of locations throughout its wide range in North America, including Maryland, New York, and Pennsylvania in the East (Hensley, 1959; Dykarcz, 1981). Regionally, albino tadpoles and metamorphs (complete loss of dark pigment, including in the eyes) have been reported from near Baltimore, Maryland (Harris, 1968). Albinistic or leucistic (total loss of body pigment but with normally pigmented eyes) late stage *Rana catesbeiana* tadpoles were collected from the Blackwater River in Franklin County and from Big Reed Island Creek in Carroll County, Virginia on 17 May 1931 (University of Michigan Museum of Zoology 70387 and 70390; J. C. Mitchell and C. A. Pague, pers. obs.). We are not aware of any other documented albinistic tadpoles of this species. Thus, in this note, we describe true albino American Bullfrog tadpoles from a mountain pond in Virginia.

On 21 May 2004 one of us (LM) collected two large (Stage 36-38, Gosner, 1960), completely albinistic *R. catesbeiana* tadpoles (Fig. 1) on Massanutten Mountain, 3.4 km N New Market Gap, Page County, Virginia (38° 40' 13.6" N, 78° 35' 43.9" W). Neither had dark body pigment and both had pink eyes. They were captured in a shallow pool adjacent to the upper reach of Passage Creek at an elevation of about 670 m (2200') on U.S. Forest Service Road 274. Numerous other tadpoles with normal pigmentation and pattern were in the sample observed. This observation represents the first record of true albinistic American Bullfrog tadpoles for a montane site in Virginia and the first reported for Page County. The tadpoles were released after photographs were taken.

LITERATURE CITED

Dykarcz, S. 1981. Recent instances of albinism in North American amphibians and reptiles. Society for the Study of Amphibians and Reptiles, Herpetological Circular 11: 1-31.

Gosner, K.L.1960. A simplified table for staging anuran embryos and larvae with notes on identification. Herpetologica 16: 183-190.

Harris, H. S. 1968. A survey of albinism in Maryland amphibians and reptiles. Maryland Herpetological Society Bulletin 4: 57-60.

Hensley, M. 1959. Albinism in North American amphibians and reptiles. Publication of the Michigan State University Museum, Biological Series. 1: 133-159.

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Fig. 1. Upper: normally-patterned and colored *Rana catesbeiana* tadpole from Massanutten Mountain, Page County, Virginia; Lower: albino *R. catesbeiana* tadpole from the same location. Photos by Liam McGranaghan.

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LEUCISTIC WOOD FROG (*RANA SYLVATICA*) TADPOLE FROM NORTHERN VIRGINIA–Albinism in North American amphibians was summarized by Hensley (1959) and Dykarcz (1981). They were unable to find a record of this phenotype for the Wood Frog. Luce and Moriarty (1999) subsequently reported an albino from Wisconsin. This tadpole was raised to adult size and became ivory yellow with a pinkish mask. The dorsum of normally colored *R. sylvatica* tadpoles is brownish gray to gray black finely speckled with gold, the venter is iridescent grayish bronze to bluish or pinkish bronze or cream, and there is a cream line that extends along the upper jaw (Wright, 1914; Ruthven et al., 1928; Vogt, 1981). Wright (1914) noted that tadpoles are usually greenish-black with fine gold and a few orange spots dorsally, and the tail has small gold flecks scattered over the surface, some of which are iridescent. These descriptions capture the normal range of color variation in *R. sylvatica* tadpoles in Virginia. Here we describe a leucistic variant for a wood frog population in northern Virginia.

On 14 March 2004, one of us (JW) collected two Wood Frog egg masses in a vernal pool in Ellanor C. Lawrence Park, 5040 Walney Road in Chantilly, Virginia (Fairfax County) along the Transcontinental Gas Pipeline (TGP) right-of-way Chantilly (38° 52' 01" N, 77° 25' 57" W). The TGP transects the second-growth hardwood area of the park and supports several ditches and low areas that fill with water during the spring. The egg masses were collected in one of these ditches. No other species were observed in the pool.

The collected egg masses were placed in a small holding pond. Development of the eggs was unremarkable and appeared to be normal. On the morning of 7 May 2004, a light colored tadpole was observed foraging among the dark leaf litter near the bottom of the pond. On discovery, the total length of the leucistic tadpole was 44 mm at Gosner stage 39 (Gosner, 1960). This tadpole lacked most of its dark body pigment and appeared somewhat golden in color (Fig. 1). It appears that with loss of the black pigment, the gold iridiphores became the most prominent color. The iris was bronze and the pupil black, the normal colors described by Wright (1914). Thus, the phenotype described here is consistent with the leucistic definition in Dyrkacz (1981).

The site where the leucistic tadpole egg mass was collected was visited several times and several thousand tadpoles were observed. All were normal in coloration; no other light-colored tadpoles were observed. The development of the tadpole appeared to be slightly behind the majority of the others in the holding pond. The majority of the tadpoles were at Gosner stage 41-42, while the leucistic tadpole was at stage 39. This is the first report of a leucistic *Rana sylvatica* tadpole in Virginia.

We thank Charise, Jennifer, and Amy White for assistance in the field.

Fig. 1. Leucistic *Rana sylvatica* tadpole and a normally colored tadpole from Fairfax County, Virginia. Photo by John White.

LITERATURE CITED

Dyrkacz, S. 1981. Recent instances of albinism in North American amphibians and reptiles. Society for the Study of Amphibians and Reptiles, Herpetological Circular 11: 1-31.

Gosner, K. L. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. Herpetologica 16: 183-190.

Hensley, M. 1959. Albinism in North American amphibians and reptiles. Publication of the Michigan State University Museum, Biological Series. 1: 133-159.

Luce, D., & J. J. Moriarty.1999. Natural history: *Rana sylvatica*. Herpetological Review 30: 94.

Ruthven, A. G. C. Thompson, & H. T. Gaige. 1928. The Herpetology of Michigan. Michigan Handbook series No. 3. Michigan University Museums. Ann Arbor, MI. 229 pp.

Vogt. R. C. 1981. Natural History of Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee, WI. 205 pp.

Wright, A. H. 1914. Life-histories of the Anura of Ithaca, New York. Carnegie Institute of Washington, Washington, DC. 98 pp.

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ANOPHTHALMIA IN AN UPLAND CHORUS FROG (*PSEUDACRIS FERIARUM FERIARUM*) FROM SOUTHEASTERN VIRGINIA—Abnormalities and malformations of eyes and limbs are well documented in North American frogs in the genus *Rana* (e.g., Ouellet et al., 1997; Meteyer, 2000; Meteyer et al., 2000) but they are less well known for other families. Banta (1968) described a case of anophthalmia in the Eastern Gray Treefrog (*Hyla versicolor*) that occurred during metamorphosis. Smith & Powell (1983) reported an adult *Acris crepitans* with a missing eye from Missouri. Two Northern Green Frogs (*Rana clamitans melanota*), one each from the City of Arlington and Fairfax County in Virginia, both of which were missing an eye, are listed in the North American Reporting Center for Amphibian Malformations website (http://frogweb.nbii.gov/narcam/). This database includes several observations of anophthalmia and other eye deformities in frogs and salamanders (e.g., *Ambystoma maculatum*, *Bufo americanus*, *Rana catesbeiana*, *R. clamitans*), but details allowing assessment of whether they were congenital or derived from injuries are unavailable.

On 3 March 2002, we found an adult male *P. feriarum* (27 mm SVL) missing its left eye and orbit in a mixed hardwood (*Acer rubrum*, *Liquidambar styraciflua*, *Ilex opaca*) swamp in the riparian zone of Beaverdam Creek, Colonial National Historical Park, 3.5 km S Yorktown, York County, Virginia (Fig. 1). This was the only malformed frog found among 17 *P. feriarum*, two *Pseudacris crucifer*, two *Rana sphenocephala*, and one *Rana palustris* captured at this location. Normally pigmented and patterned skin entirely covered the orbit, and the frog did not appear injured, scarred, or unusual except for the missing eye. Thus, the abnormality appears to be congenital. This is the first report of anophthalmia for *Pseudacris feriarum*.

LITERATURE CITED

Banta, B. H. 1968. A supernumerary forelimb on a Spring Peeper, *Hyla crucifer crucifer* Wied (Amphibia: Salientia) from south central Michigan. Wasmann Journal of Biology 26: 263-265.

Meteyer, C. U. 2000. Field Guide to Malformations of Frogs and Toads with Radiographic Interpretations. U.S. Geological Survey, Biological Science Report, USGS/BRD/BSR-2000-0005, Madison, WI. 18 pp.

Meteyer, C. U., I. K. Loeffler, J. G. Burkhart, K. A. Converse, E. Green, J. C. Helgen, S. Kersten, R. Levey, L. Eaton-Poole, & J. F. Fallon. 2000. Hind limb malformations in free-living Northern Leopard Frogs (*Rana pipiens*) from Maine, Minnesota and Vermont suggest multiple etiologies. Teratology 62: 151-171.

Ouellet, M., J. Bonin, J. Rodrigue, J-L. DesGranges, & S. Lair. 1997. Hindlimb deformities (ectromelia, ectrodactyly) in free-living anurans from agricultural habitats. Journal of Wildlife Diseases 33: 95-104.

Fig. 1. Adult male *Pseudacris feriarum* with left-side anophthalmia from York County, Virginia.

Smith, D. D., & R. Powell. 1983. Life history: *Acris crepitans blanchardi* (Blanchard's Cricket Frog) anomalies. Herpetological Review 14: 118-119.

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BILATERAL ECTROMELIA IN A NORTHERN CRICKET FROG (*ACRIS CREPITANS CREPITANS*) METAMORPH FROM VIRGINIA—Most malformations in frogs have been reported for metamorphs or juveniles (e.g., Ouellet et al., 1997; Meteyer, 2000; Meteyer et al., 2000). Deformities in tadpoles are occasionally reported based on experimental work or from contaminated environments (Rowe et al., 1998). In the genus *Acris*, polydactyly in *A. gryllus* was reported from Florida by Christman (1970) and malformations consisting of a missing eye and subcutaneous bloating derived from a herniated small intestine were described for *A. c. blanchardi* in Missouri by Smith & Powell (1983). Gray (2001) noted that 39 of 9,987 recently metamorphosed *A. c. blanchardi* froglets from Illinois had missing limbs and digits and deformed or extra limbs, digits, or mouthparts. The North American Reporting Center for Amphibian Malformations website (http://frogweb.nbii.gov/narcam/) reports four species of ranids and an American toad (*Bufo americanus*) with multiple legs but none with ectromelia (missing limbs). No reports concern tadpoles. Here we report the first documented observation of ectromelia in a metamorphic *A. crepitans crepitans*.

On 29 July 2003, we captured a 30 mm total length *Acris c. crepitans* tadpole in a tire rut pool in a clearcut on Fort Lee (U.S. Army), Prince George County, Virginia (UTM 4126859 N, 18s 293184 E, NAD 83). Both of the anterior limbs were fully formed with complete development of both hands and digits. Both rear limbs were absent, with only small, fleshy stumps at the point of emergence from the body (Fig. 1). There was no evidence of predation or injury. The dark areas on the stumps are melanophores; there is no bone tissue exposed. We interpret this observation as an instance of congenital bilateral ectromelia. Twenty other *A. crepitans* tadpoles with rear legs only were also captured at this site, as were two metamorphs with

Fig. 1. *Acris c. crepitans* tadpole from Virginia with bilateral ectromelia.

all four limbs and a tail. None of these larvae showed signs of malformations. No obvious environmental or military training factor contributed to this malformation. All tadpoles and metamorphic frogs that are captured should be examined closely for abnormalities because they may represent unique cases or indications of more severe problems.

LITERATURE CITED

Christman, S. P. 1970. A three-legged cricket frog from Florida. Bulletin of the Maryland Herpetological Society 6: 9-10.

Gray, R. H. 2001. Cricket frog, *Acris crepitans*, malformations in Illinois, past and present. Herpetological Natural History 8: 75-77.

Meteyer, C. U. 2000. Field Guide to Malformations of Frogs and Toads with Radiographic Interpretations. U.S. Geological Survey, Biological Science Report, USGS/BRD/BSR-2000-0005, Madison, WI. 18 pp.

Meteyer, C. U., I. K. Loeffler, J. G. Burkhart, K. A. Converse, E. Green, J. C. Helgen, S. Kersten, R. Levey, L. Eaton-Poole, & J. F. Fallon. 2000. Hind limb malformations in free-living northern leopard frogs (*Rana pipiens*) from Maine, Minnesota and Vermont suggest multiple etiologies. Teratology 62: 151-171.

Ouellet, M., J. Bonin, J. Rodrigue, J-L. DesGranges, & S. Lair. 1997. Hindlimb deformities (ectromelia, ectrodactyly) in free-living anurans from agricultural habitats. Journal of Wildlife Diseases 33: 95-104.

Rowe, C. L., S. M. Kinney, & J. D. Congdon. 1998. Oral deformities in tadpoles of the bullfrog (*Rana catesbeiana*) caused by conditions in a polluted habitat. Copeia 1998: 244-246.

Smith, D. D., & R. Powell. 1983. Life history: *Acris crepitans blanchardi* (Blanchard's Cricket Frog) anomalies. Herpetological Review 14: 118-119.

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MORTALITY OF LARVAL SPOTTED SALAMANDERS (*AMBYSTOMA MACULATUM*) IN A CENTRAL VIRGINIA ROAD RUT PUDDLE— Several species of frogs and salamanders in the mid-Atlantic region use vernal pools for egg deposition and larval development (Mitchell, 2000). Road rut puddles of various sizes that often act like vernal pools are used extensively by amphibians such as Spring Peepers (*Pseudacris crucifer*), Wood Frogs (*Rana sylvatica*), Green Frogs (*Rana clamitans*), American Toads (*Bufo americanus*), Fowler's Toads (*B. fowleri*), Red-spotted Newts (*Notophthalmus viridescens*), Marbled Salamanders (*Ambystoma opacum*) and Spotted Salamanders (*A. maculatum*) (pers. obs.). Such ephemeral aquatic environments are susceptible to early drying that could result in complete mortality of the entire cohort of offspring. Drying pools are also attractive to predators such as crows, herons, and raccoons (pers. obs.). Mortality from disease organisms in such environments has not been previously reported. The biology and effects of various diseases such as ranaviruses (Family: Iridoviridae), ichthyophoniasis and chytridiomycosis have been studied in places other than the mid-Atlantic (Docherty et al., 2003). In Virginia, diseases have caused mortality in Southern Leopard Frogs (*Rana sphenocephala utricularia*) in Virginia Beach and larval Wood Frogs (*R. sylvatica*) in Augusta County (D. E. Green, pers. comm.). Multiple die-offs of Spotted Salamanders in the southern Appalachians have been attributed to ranaviral epizootics (Converse & Green, 2005). In this paper, I describe a mortality event for *A. maculatum* larvae in a central Virginia road rut puddle and note possible disease agents that may have caused this die-off.

On 3 June 1998, I observed large numbers of dead *A. maculatum* larvae in two shallow road rut puddles on a plant nursery road 1.6 km W Midlothian, Chesterfield County, Virginia. One pool measured 5 m long x 1m wide x 4 cm deep, and the other measured 7.5 m long x 1.3 m wide x 5 cm deep. Each pool had a clay substrate with little organic matter or algae. There was no emergent vegetation and the water was clear. Most of the margins of each pool were bordered by grass. Mixed hardwoods and pine on both sides of the road afforded shading in the morning and late afternoon. The afternoon temperature was about 32° C and there had been no rain for at least two days. I was unable to take water temperature but it was warm to the touch. The number of dead *A. maculatum* larvae was not counted, although there were about 2-3 scores of them. Not all of

the larvae were dead, as there were numerous live individuals among the dead ones. Those that had died were floating at the surface and lying on the substrate, nearly all with the ventral side up. Several were bloated around the head and neck. The live larvae were colored and behaved normally; swimming speed and response to touch was normal. Most of these had reduced gills and were nearing metamorphosis. One *N. viridescens* adult was in each of the two pools. Frogs in these pools were a juvenile Northern Green Frog (*Rana. clamitans*) and several adult Northern Cricket Frogs (*Acris crepitans*). I found no dead individuals of any of these species. No tadpoles of any anuran were present.

I had originally hypothesized that the mortality event was due to excessive heat. However, bloating of the gular skin and ventrum in ambystomid larvae are common signs of ranaviral infection (Converse & Green, 2005). I also found *A. maculatum* larvae in other warm aquatic sites during the same week that exhibited no mortality. The area within the nursery where the pools were located was apparently not subject to fertilizer, herbicide, or pesticide applications (W. H. Mitchell, pers. comm.). Such mortality events should be recorded because numerous reports of amphibian population die-offs are due to disease outbreaks (Daszak et al., 1999; Carey, 2000; Chinchar, 2002). Detailed descriptions of the event should be taken, and freshly dead amphibians should be promptly frozen or fixed for diagnostic examinations. The frozen samples I salvaged were accidentally discarded later. My observation of a mortality event in larval spotted salamanders with ventral and gular subcutaneous edema, although in a road rut puddle, suggests that infectious disease may have contributed to the deaths. Furthermore, the paucity of larval anurans in the road rut puddles suggests they had died several days earlier and the dead larval spotted salamanders were detected near the end of a ranaviral epizootic (D. E. Green, pers. comm.). Thus, other observations of such dead amphibians should be treated as a die-off and the proper procedures and specimens taken for definitive analysis.

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I thank David E. Green for his comments on this note and for the citations he provided.

LITERATURE CITED

Carey, C. 2000. Infectious disease and worldwide declines of amphibian populations, with comments on emerging diseases in coral reef organisms and humans. Environmental Health Perspectives 108: 143-150.

Chinchar, V. G. 2002. Ranaviruses (Family Iridoviridae): emerging cold-blooded killers. Archives of Virology 147: 447-470.

Converse, K. A., & D. E. Green. 2005. Diseases of salamanders. Pp. 118-130 *In* S. K. Majumdar, J. Huffman, F. J. Brenner & A. I. Panah (eds.), Wildlife Diseases: Landscape Epidemiology, Spatial Distribution, and Utilization of Remote Sensing Technology. Pennsylvania Academy of Science, York, PA.

Daszak, P, L. Burger, A. A. Cunningham, A. D. Hyatt, D. E. Green, & R. Speare. 1999. Emerging infectious diseases and amphibian population declines. Emerging Infectious Diseases 5: 1-21.

Docherty, D. E., C. U. Meteyer, J. Wang, J. H. Mao, S. T. Case, & V. G. Chinchar. 2003. Diagnostic and molecular evaluation of three iridovirus-associated salamander mortality events. Journal of Wildlife Diseases 39: 356-366.

Mitchell, J. C. 2000. Amphibian monitoring methods and field guide. Smithsonian National Zoological Park, Front Royal, VA. 56 pp.

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Miscellanea

Reviews

A Pirate of Exquisite Mind - Explorer, Naturalist, and Buccaneer: The Life of William Dampier. 2004. Diana & Michael Preston, Berkeley Books, New York, NY. 372 pp. ISBN 0-425-20037-X (paperback). $15.00.

I picked up this book in a local bookstore because it dealt with natural history, exploration, and biography; and because it had an Eastern Box Turtle (*Terrapene carolina carolina*) on the front cover walking across a late 1600s map of, of all places, Europe and Great Britain. Well, it is an eye-catching cover. Not knowing what to find inside, I ventured in and found a tale based on an amazing amount of detailed research and writings on a relatively unknown man who made very important contributions to global natural history, oceanography, and anthropology; a man who at the same time was a pirate and forever yearning to see new places. He was a man who could not help himself but to write down all of his observations. William Dampier (circa 1651-1715) was a contemporary of John Banister, for whom this journal is named. Banister is not mentioned in the book so we do not know if they knew each other. However, while Banister was busy working on the natural history of Virginia, Dampier was busy in his own way. He circled the globe three times between 1674 and 1711 and made numerous observations that had great influence on others to follow. They include such well-known names as Daniel Defoe (*Robinson Crusoe*), Jonathan Swift (*Gulliver's Travels*), Captain James Cook, Charles Darwin, and Alexander von Humboldt.

In my review, of an unlikely book for this journal at least, I point out some of Dampier's observations and contributions to natural history and embellish the story with some pirate anecdotes. Some of his descriptions are quite fascinating and many of his terms and descriptions were the first for the English language. Indeed, the origins of some 1,000 words in the Oxford English Dictionary are attributed to him. These include avocado, barbecue, breadfruit, cashew, chopsticks, kumquat, posse, serrated, tortilla, stilts, and rambling. He combined words for the first time, such as sea and lion and sea and breeze.

Sir Francis Bacon, pioneer of the science of "natural philosophy," no doubt influenced Dampier. Bacon and, subsequently, the Royal Society espoused geographic exploration with the expansion of scientific knowledge. In the 1660s, they drew up a document called "Directions for Seamen Bound for Far Voyages," and asked those interested to study nature from direct observations rather than from old books. Dampier was apparently the only one to respond. His writings from his three voyages were published in three books – "*A New Voyage Round the World*" (1697), "*Voyages and Descriptions*" (1699), and "*A Voyage to New Holland*" (two parts, 1703 and 1709). New Holland later became known as Australia.

Dampier was the first English naturalist to visit all five continents and compare and contrast plants, birds, reptiles, and other animals around the planet. He preceded the likes of Alfred Russell Wallace and Charles Darwin by over 100 years. The latter used Dampier's books during his voyage on the *Beagle*, and some of Darwin's observations were included in his famous red notebook in which he formulated his theory of natural selection. Unfortunately, like John Banister, Dampier was not until recently given proper credit for his scientific and cultural contributions. It happened to Banister because others did not give him due credit, and to Dampier because he was also a pirate, a buccaneer, whose life style on the high seas was looked on with distain by people of his era. The Prestons weave both of these aspects of Dampier's life into an enjoyable and very readable book.

The book starts in the Prologue with Dampier's 1683 description of flamingos and their life history on the Cape Verde Islands off the west coast of Africa. He also noted, being a hungry 17th century sailor, how well they taste, especially their tongues. At the same time his shipmates were plotting to seize a better ship for their voyage to the South Seas. Such was the nature of Dampier's life, descriptions of nature or people in other lands while worrying about how to escape the Spanish whose ships they were seeking to rob for their gold and other valuables.

Dampier's travels took him to Jamaica, Mexico, Panama, Venezuela, along the coast of western South America, the Galapagos Islands, Guam, the Philippines, China, Vietnam, Sulawesi, Sumatra, India, Australia, New Guinea, and many other places in between. He was the first person to publish a description of the Aborigines. An Australian tree (*Eucalyptus dampieri*) honors his discovery and description of that plant. His maps were quite accurate and used by English ship's captains for decades.

He even lived in Virginia for 13 months during 1682-1683. Jamestown colony had been established in 1607 as a commercial trading post and by Dampier's arrival boasted some 20-30 million pounds of exported tobacco annually. He and the other seamen had hoped of selling their captured wares and living for a time in comfort. They settled on the Eastern Shore but another

pirate party raided Virginia shortly thereafter and the authorities made life difficult for all pirates. Dampier said little about Virginia and apparently left little in the way of notes and observations on its plants and wildlife. In 1688, other pirates were captured near the Chesapeake Bay and the silver in their sea chests confiscated; this pirate loot was later used to partly found the College of William and Mary.

Dampier loved to eat green sea turtles (*Chelonia mydas mydas*), having first tasted them in the Caribbean. However, he also observed them closely and made numerous observations. He noticed that the Green Turtles in the Pacific were different from those in the Atlantic, and called them "bastard" turtles. Some turtle taxonomists even today regard the Pacific populations as a different subspecies, *Chelonia mydas agassizii*, vindicating Dampier's keen eyes. This, and other observations of animals between different locations, especially waterfowl in Brazil, led to his original concept and coinage of the word "subspecies." He observed that green sea turtles mate offshore, lay 70-100 eggs at a time in a nest on the beach, that a female would lay several times a year, and that they migrate long distances from their foraging grounds to their nesting beaches. These observations would be proven with modern techniques some three centuries later. Dampier, like other sailors reaching the Galapagos, loaded their ship with the abundant giant tortoises (*Geochelone elephantopus*), or saddlebacks (*Galapagos* is Spanish for saddleback). He noted how sweet the succulent flesh was to eat, and calculated that they captured tortoises ranging in size from 30 to about 200 pounds.

Dampier essentially pioneered the field of descriptive zoology. His description of an armadillo is thorough (only partly quoted here)– "The body is pretty long, this creature is enclosed in a thick shell, which guards all its back, and comes down on both sides and meets under the belly leaving room for its four legs. The head is small with a nose like a pig, a pretty long neck, and can put out its head before its body when it walks; but on any danger, she puts it under the shell, and drawing in her feet lies stock-still like a land turtle." He also noted that the flesh is sweet and tastes like a land turtle. He contrasted in scientific detail the differences between alligators and crocodiles. He was the first to describe the fruit bat, flying fox, monkfish, and zebra in English and the second to describe marijuana. He collected plant specimens from Australia and other places; some remain in existence today at Oxford University. John Ray and Leonard Plukenet described several specimens new to science based on Dampier's specimens.

I wondered as I read this book if I could weather all the physical hardships, mental anguish, medical problems, parasites, and lack of food and amenities we take for granted today and still produce copious notes and observations on natural history, navigation, tides, maps, etc. like Dampier did. I am not sure I could have even when I was in my best physical shape. Dampier's notes, journals, and specimens are a testament to a man who persevered under extreme conditions to pursue his passion. It is somewhat disappointing though, to know that there was so much new natural history and places to see and describe in his era and none of the like has been left for us. We can now only read about visiting pristine places such as Sumatra and Australia for the first time, to describe their human inhabitants, and to see new species and even taste them. The combination of a pirate's life style with that of a naturalist with an insatiable mind for observations and writing them down is well captured in this book.

If you like to read about adventures on the high seas, the lives of pirates, their successes and disappointments, and about early natural history, then this is the book for you. I was not sure what I was getting into when I picked it up, but I am better informed about the history of natural history and the lives of pirates in the 1600s than before that image of the box turtle on the cover caught my eye.

Joseph C. Mitchell
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Reports

1. President's Report

As incoming President of VNHS, I am writing this in gratitude both for those who have agreed to serve as of the fall 2004 election (Vice President Thomas McAvoy, Secretary-Treasurer Anne Lund, and Councilor Arthur Evans) and those who have served the organization in the past. It is an exciting time for natural history in Virginia with a new state museum building now going up. But, as pointed out below, membership numbers are down this year, and we need to make a strong effort to recruit new members and to retain old ones. We are not the only organization to be so affected. The spring newsletter of the American Microscopical Society (which publishes the journal *Invertebrate Biology*) pointed out a similar trend, noting also that it was only US memberships that were

declining. International memberships and submissions to the journal were increasing. Should we be recruiting new members beyond Virginia's borders? Most of us are scientists or students and we appreciate the value of *Banisteria* as a membership benefit, but is there something else we could be doing to attract more amateur naturalists? If you've got an idea, send it to me (jwinston@vmnh.net), and we can discuss it at the next council meeting.

Judith E. Winston, VNHS President
Virginia Museum of Natural History
1001 Douglas Avenue
Martinsville, VA 24112

2. Minutes of Fall 2004 Council Meeting

Hampden-Sydney College, Gilmer Hall, Hampden-Sydney, Virginia, November 20, 2004

Council members in attendance: Barbara Abraham, Steve Roble, Dick Neves, Michael Kosztarab, Richard Hoffman, Tom McAvoy, Judy Winston, Paul Bedell, and Anne Lund.

Barbara Abraham, Society president, presided.

The minutes of the November 22, 2003 Council meeting had been approved earlier.

The secretary/treasurer reported a membership of 155 (paid for 2004), compared to 166 at the end of 2003, with a balance on hand, as of October 31, 2004, of $4,731.75. A membership list was circulated for council members to gather information and to correct any errors.

The editors reported that the fall issue of *Banisteria* was not ready but would go to press early in 2005. It was suggested that the photos in the last issue were not as good quality as the editors would like and that the printer that was used was also slow to get the issue out. Richard Hoffman proposed going back to the printer that we had used previously. It was decided that the editors and Dr. Hoffman would decide on the printer by email.

Old Business included a discussion of BioBlitz 2004. It was reported that the site for this year had been smaller and had limited diversity. There was continued discussion of how and when these results would and should be reported. The BioBlitz proposed for the Potomac River (Maryland and Virginia shores) has been postponed to June 2006. There was discussion of a possible site for BioBlitz 2005 in Chesterfield County, with a possible grant available being worked on by Cyrus Brame of the U.S. Fish and Wildlfe Service. Other sites for BioBlitz surveys, a BioBlitz Committee, and the possibility of BioBlitz in connection with the VAS meeting were discussed. It was decided that $200 from the treasury will be set aside for BioBlitz 2005.

Also under Old Business, there was a discussion of membership. It was decided that we would not send journals to those who had not renewed for the year. Membership notices will be sent out in a separate mailing.

Under new business, the Back Bay Symposium was discussed, but the information concerning this event was incomplete. It was agreed that starting this year abstracts and keywords of all regular articles published in Banisteria will be posted on the web site in *pdf* files, and the full text of a few selected articles from past years will be posted as *pdf* files with the author's permission. Color photos will also be published on the web site that relate to papers in the journals. There was a discussion of and an agreement to include the Webmaster on the executive committee. The ballot for elections for 2005 will be sent out with the membership announcement with bios of the candidates: Tom McAvoy—Vice President; Anne Lund—Secretary/ Treasurer; and Art Evans—councilor.

Respectfully submitted,
Anne Lund, Secretary/Treasurer

3. Secretary/Treasurer's Report

As of July 7, we have 113 members for 2005, 14 of which are institutions or libraries. This compares unfavorably with our final membership for 2004 of 165 members, of which 21 were institutions. Another renewal notice will be sent to delinquent members to encourage them to rejoin the society. Our treasury holds $4,962.54 as of July 1, 2005.

As always, we encourage our active members to recruit members for the Society. A membership form is included with this mailing. Please pass it on to a friend or colleague interested in the natural history of our state.

We continue to be grateful to Hampden-Sydney College for support with the paperwork concerning our treasury and membership records. The secretary of Gilmer Hall, Hampden-Sydney College, Beckie Smith, has done a great job of keeping our records of membership, and she has prepared the address labels for all mailings. We thank her for her dedication to these tasks, and we thank Hampden-Sydney College for supplying this support to the Society.

Please submit all enquiries about membership in the Society or about past issues of *Banisteria* to: Dr. Anne Lund, Virginia Natural History Society, Box 62, Hampden-Sydney, Virginia 23943, or email, alund@hsc.edu .

Respectfully submitted,
Anne Lund, Secretary/Treasurer

4. Coeditors' Report

The current issue of *Banisteria* (Number 25, a milestone for our society) contains a mix of floral, invertebrate, and vertebrate (many of them herpetological) articles that illustrate the diversity of topics we seek for this journal. Unfortunately, as of mid-summer we have very few papers slated for Number 26; thus we are again in the position of being concerned about the number of manuscripts we will have for the next issue. We need full-length papers and smaller contributions. Please think about *Banisteria* for those unpublished theses and reports that include valuable natural history information. Contribute to the permanent natural history record for Virginia. Instructions to Authors for *Banisteria* submissions can be viewed on the VNHS website (http://fwie.fw.vt.edu/vnhs).

We thank Will Brown for his excellent photographic illustration of a copperhead on the inside back cover. His interest and skills in transforming digital images into images that look like 18th and 19th century photolithographs are greatly appreciated.

All of the titles published in *Banisteria* from origin to present are on the VNHS website. We thank John White for maintaining this professional site. Selected papers published in *Banisteria* will soon to added to this site in PDF format; you will only need Adobe reader to download them. Finally, we are limited in publishing photographs in the journal to black and white but on the website we can use color. Website PDFs with the color photos tend to the modern European tradition of publishing color photographs in natural history articles.

Finally, we thank all the subscribers and authors for their support of *Banisteria*. As noted above, the VNHS has experienced a downturn in subscriptions and memberships. Without your support this natural history journal will not be able to survive.

Respectfully submitted,
Joe Mitchell and Steve Roble, Co-editors

Announcements

1. Recent Publications

A Field Guide to Moths of Eastern North America, by Charles V. Covell, Jr. 2005. Virginia Museum of Natural History Special Publication No. 12, Martinsville, VA. 495 pp., 64 plates (half in color) and 74 line drawings. $40.00 (paperback), postage included if purchasing one copy; Virginia residents add $2.00 for sales tax. A reprint edition of this "Peterson" field guide, originally published in 1984 and out of print for nearly a decade, is now available. It is essentially the only field guide available to a large portion of the moth fauna of eastern North America and includes detailed descriptions of over 1,300 species. Phone orders: 276-666-8600; website: www.vmnh.net/index.cfm?pg=329

Snakes of the Southeast, by Whit Gibbons & Mike Dorcas. 2005. University of Georgia Press, Athens, GA. 253 pp. $22.95 (paperback) plus $4.50 postage and handling. This new book covers the southeastern United States from Virginia through Tennessee and Louisiana and has over 300 color photographs. Check out this book on their website (www.ugapress.org) if you are interested in this vertebrate group.

Amphibian Declines, The Conservation Status of United States Amphibians, edited by Michael Lannoo with over 215 contributors. 2005. University of California Press, Berkeley, CA. 1,024 pp. $95.00 plus handling and postage. This book covers every known species of frog and salamander in the United States, and is currently the only book in existence that does so. This modern reference has 50 essays by amphibian biologists on the topic of amphibian decline and species accounts of all species. Website: www.ucpress.edu

2. Northeast Partners in Amphibian and Reptile Conservation (NEPARC), 2005 annual meeting, Biden Environmental Training Center, Cape Henlopen State Park, Delaware, 23-25 August 2005. Agenda topics include updates on projects, iridoviruses in reptiles and amphibians, comprehensive wildlife ranking, conservation of box turtles, mitigation measures for the Lake Jackson ecopassage in Tallahassee, Florida, using GIS techniques to protect vernal pools, and a keynote address by Jim White and Bill McAvoy on "Amphibian brothels: unpronounceable plant names and whale wallows: what the heck is a Delmarva Bay?" Contact Holly Niederriter for information (holly.niederriter@state.de.us; 302-653-2880).

Copperhead

Agkistrodon contortrix

Greene County, Virginia

del. W. Brown